STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS

Publications of the
DIVISION OF WATER RESOURCES
EDWARD HYATT, State Engineer

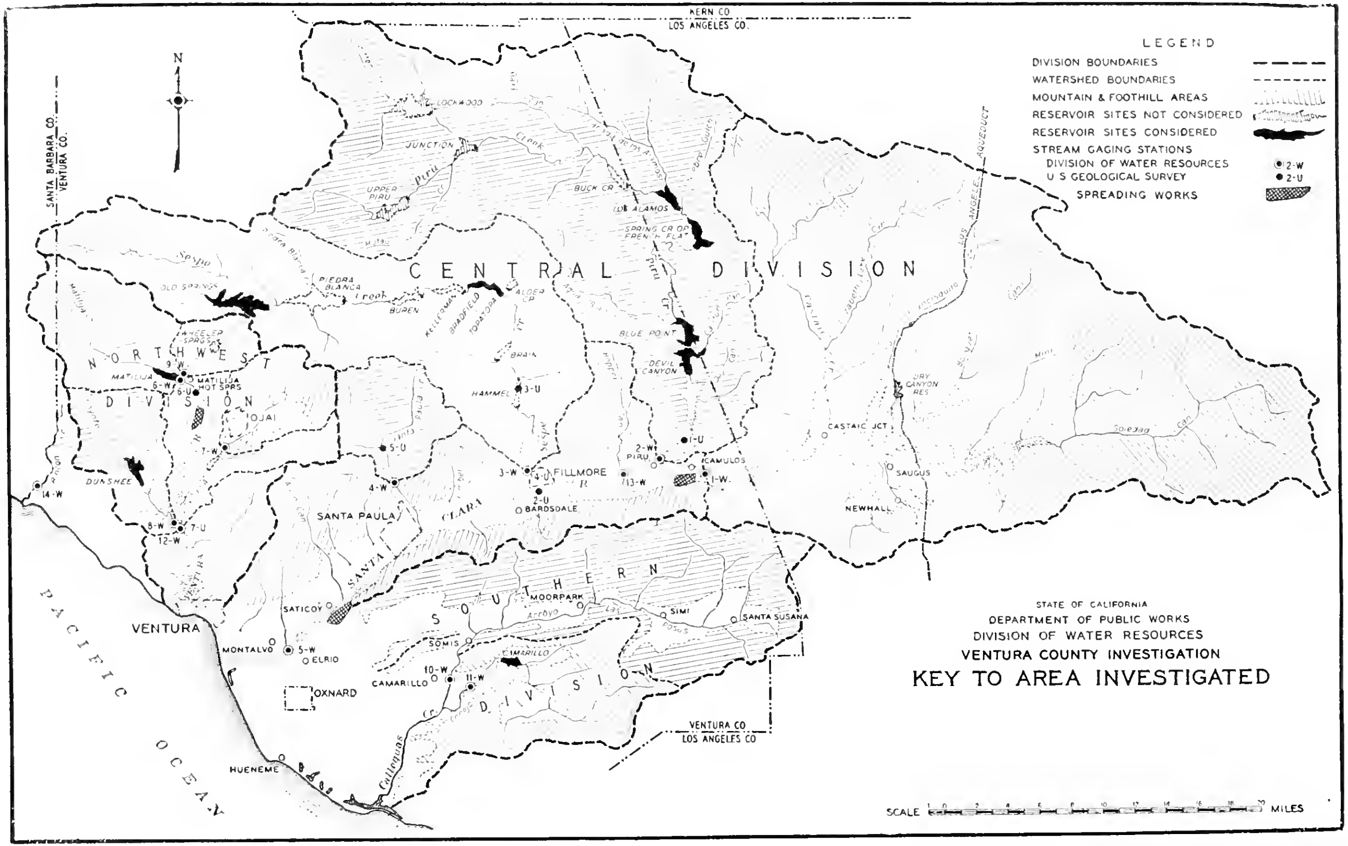
Bulletin No. 46

VENTURA COUNTY INVESTIGATION

1933

CALIFORNIA STATE PRINTING OFFICE
HARRY HAMMOND STATE PRINTER
SACRAMENTO, 1934

8367—8375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ACKNOWLEDGMENT

When the investigation was started a committee representing the various interested areas of the county was formed to aid the engineers of the division in their work. The aid of the committee is gratefully acknowledged and particularly that of V. M. Freeman, Managing Engineer of Santa Clara Conservation District, and Charles Petit, County Surveyor, who contributed their time and assistance most helpfully.

The aid of other residents of Ventura County has been material but their names are too numerous to mention.

The assistance of Harry F. Blaney, Irrigation Engineer, U. S. Department of Agriculture, and C. S. Scofield, Principal Agriculturist in Charge Division of Western Irrigation Agriculture, U. S. Department of Agriculture, in writing chapters on their respective specialties is appreciated.

ORGANIZATION

EARL LEE KELLY __________________________ *Director of Public Works*

EDWARD HYATT __________________________________ *State Engineer*

The investigation was under the supervision of and this report is by

HAROLD CONKLING
Deputy State Engineer

In field charge was
R. H. JAMISON
Senior Hydraulic Engineer

Geological investigation of dam sites was made
under the supervision of
GEORGE HAWLEY
Deputy State Engineer
by
CHESTER MARLIAVE
Senior Engineer Geologist

Cost of reservoirs was estimated under the supervision of
A. D. EDMONSTON
Deputy State Engineer
by
T. B. WADDELL
Senior Hydraulic Engineer

General geology and capacity of underground basins are by
A. W. GENTRY
Junior Engineer Geologist

Water supply studies are by
GARFIELD STUBBLEFIELD
Senior Hydraulic Engineer
and
P. E. STEPHENSON
Supervising Hydraulic Engineer-Draftsman Computer

Others on the field staff were

P. H. VAN ETTEN — C. T. JUDAH
ARTHUR C. DUNLOP — HERVEY GULICK
A. M. WELLS — J. T. MCGUIRE
JOHN PARENTI

PERMANENT COMMITTEE

Santa Clara Protective Association

A. C. Hardison, Santa Paula
V. M. Freeman, Santa Paula

Moorpark-Conejo Irrigation District

Frank Gillelen, Los Angeles
P. L. Wicks, Moorpark

Newhall Company

A. S. Cheesborough, Piru

Ojai Valley

G. T. Stetson, Ojai

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Piru Domestic Water Company and
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Hugh Warring, Piru

FOREWORD

Ventura County investigation was initiated to resolve a conflict caused by the filing of applications to appropriate water from the extreme headwaters of Sespe Creek and convey it to lands in Ventura River Basin and also by the initiation of applications to appropriate from Sespe and Piru Creeks and convey water to lands in Calleguas Creek Basin in the vicinity of Moorpark.

Hydrological data at hand were not sufficient for intelligent conclusion as to the effect of these two proposed projects on the water supply of Santa Clara River Valley into which Sespe and Piru Creeks drain and at the request of local interests the State appropriated funds to finance an investigation during that biennium provided such funds were matched equally from local sources. The county board of supervisors appropriated the matching funds. The problem encountered proved very complicated and its solution required observations during at least one approximately normal run-off year. Until the winter of 1931–32 the rainfall was extremely deficient thus prolonging the period of investigation but adding materially to the basic data available.

During the progress of the investigation its scope was broadened at the request of local interests to comprehend a plan for complete utilization of the water supplies of Ventura County. In 1931 the State Division of Highways began reconstruction of the highway between Los Angeles and Bakersfield on a location which passes through two reservoir sites on Piru Creek the construction of which was locally thought to be the necessary first step in this plan and as a result of the ensuing controversy the scope was again broadened and the Division of Water Resources made a particularly intensive investigation of the most desirable plan for conservation of the flood waters of Piru Creek. Funds for this phase of the investigation were provided locally and by the Division of Highways.

VENTURA COUNTY INVESTIGATION

CHAPTER I

SUMMARY AND CONCLUSIONS

The portion of Ventura County of which the water supply was investigated, and for which plans of development have been made, is shown on frontispiece and involves the drainage basins of Ventura River, Santa Clara River, and Calleguas Creek together with the Coastal Plain comprising the entire habitable portion of the county. Field work started in August, 1927, and was finished in September, 1932, a period of five complete years. Of these the first four years were extremely deficient in rainfall but in the last it varied from 15 to 35 per cent above the long-time average.

Work Done

Data were secured on stream flow at all strategic points, percolation into underground basins, and rainfall at all locations at which records had been kept. In addition new records were started. Geology of the region was studied with special reference to its relation to water supply. Most of the water supplies of the county are drawn from the recent alluvials of the valleys which were mechanically analyzed to secure estimates of capacity of the underground reservoirs. Quality of water was investigated and all analyses by others available were utilized together with new analyses made during this investigation.

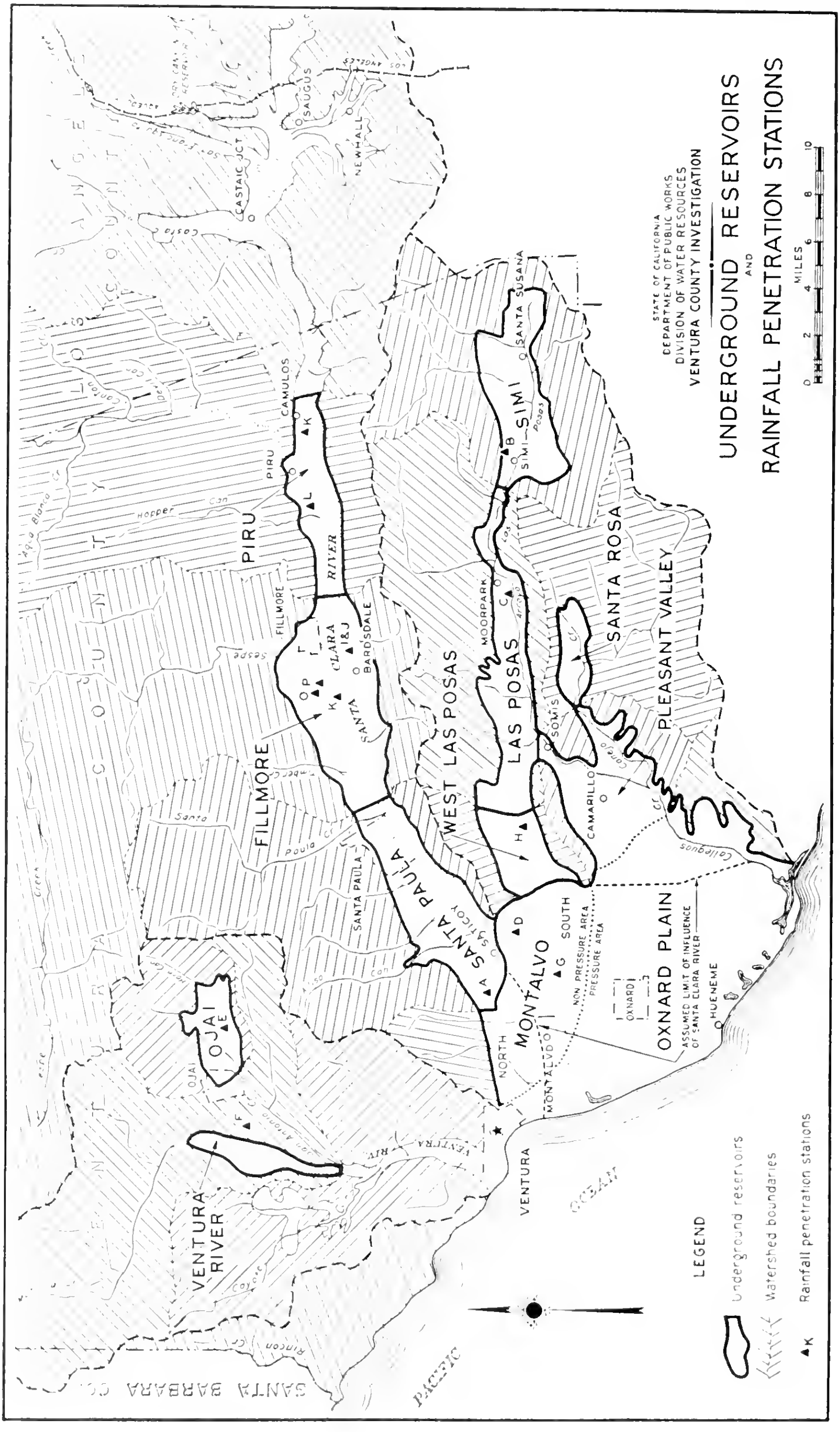
Measurements at wells to determine depth to water table were made consistently and all former measurements available were secured. For water supply estimates the entire area of the county was divided into basins as shown on Plate I, and each basin was studied individually.

From recorded stream discharges and rainfall records the discharge by months for each of the forty years beginning with fall 1892 was reconstructed, percolation was calculated and operation of underground reservoirs was reconstructed during the forty years on the basis of present draft. The yield of each of the various surface reservoirs studied was estimated and the cost per acre-foot of yield calculated.

A careful crop survey was made for the entire area. Estimates of present draft on the underground reservoirs and of the ultimate area possible to irrigate were made. Available statistics on irrigated areas at various times in the past were secured.

A plan for a comprehensive development of the water supply was made and cost estimates were made of all the most favorable surface

PLATE 1


STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
UNDERGROUND RESERVOIRS
AND
RAINFALL PENETRATION STATIONS
MILES
0 2 4 6 8 10
LEGEND
Underground reservoirs
Watershed boundaries
Rainfall penetration stations
VENTURA RIVER
OJAI
SANTA PAULA
FILLMORE
PIRU
WEST LAS POSAS
LAS POSAS
SIMI
SANTA ROSA
PLEASANT VALLEY
MONTALVO
NORTH
SOUTH
OXNARD PLAIN
NON PRESSURE AREA
PRESSURE AREA
ASSUMED LIMIT OF INFLUENCE OF SANTA CLARA RIVER
SANTA CLARA RIVER
VENTURA
MONTALVO
OXNARD
HUENEME
CAMARILLO
SOMIS
MOORPARK
SANTA SUSANA
BARDSDALE
SANTA PAULA
CAMULOS
CASTAIC JCT
SAUGUS
NEWHALL
SANTA BARBARA CO.
PACIFIC
OCEAN

reservoirs for different capacities and different types of dams. Cost estimates were made of spreading grounds to artificially recharge underground basins and also of conduits and various other items involved in the plan.

WATER SUPPLY

Basic Assumption

The forty-year period beginning fall 1892 is assumed to have established a normal or long-time average rainfall and run-off. All conclusions as to water supply are made on this assumption.

Summary

Santa Clara River is the principal stream system of the county with an estimated average annual discharge of 214,000 acre-feet of which an average of 152,000 acre-feet wastes into the ocean. The next stream system in size is Ventura River with an average run-off estimated at 76,000 acre-feet of which 68,000 acre-feet wastes into the ocean. No estimate was made of the run-off or waste into ocean of Calleguas Creek but the run-off comparatively is small and waste into ocean is negligible.

The area irrigated in Ventura County has grown from approximately 25,000 acres in 1909 to 107,000 acres in 1932. In recent years the growth has been accelerated. In 1932 over 25,000 acres were in citrus groves and over 22,000 acres in walnut groves, both of which crops are able to pay high prices for irrigation water.

The present irrigated area including municipalities and subdivisions and the estimated total remaining area which might be irrigated. is as follows:

TABLE 1

IRRIGATED AND IRRIGABLE AREA, 1932†

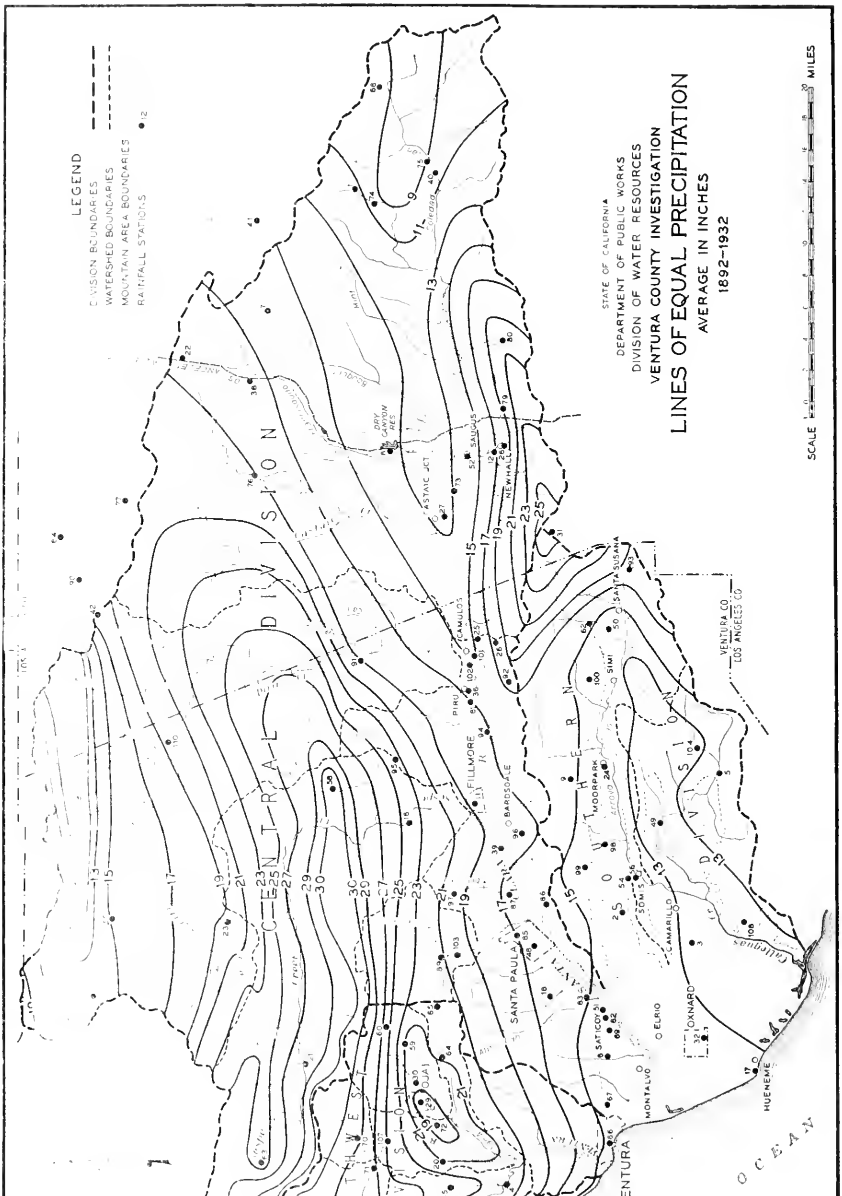
Acres—Round figures

Area	Irrigated			Irrigable		
	Hill	Valley	Total	Hill**	Valley***	Total
Santa Clara River Basin*	800	23,600	24,400	2,100	9,600	11,700
Ventura River Basin	100	4,400	4,500	1,800	9,900	11,700
Calleguas Creek Basin	2,300	35,100	37,400	11,900	17,100	28,000
Coastal Plain	200	44,800	45,000	500	6,000	6,500
Totals	3,400	107,900	111,300	16,300	42,600	57,900

*Including Los Angeles County, see Plates B and C in rear pocket.
**25% of area marked "irrigable or habitable" on plates in rear pocket.
***75% of unirrigated but irrigable land on plates in rear pocket except in Oxnard Plain and Pleasant Valley where the factor used is 50%.
†See Table 1-A on page 218 for another estimate.

Rainfall is small over the entire region and decreases to the east in general as shown by Plate II. Records indicate that wet and dry periods of years succeed each other so that it is common to speak of wet and dry cycles. Variation in run-off of the streams is much more extreme than variation in rainfall. Change in precipitation produces change in recharge of the underground basins and the water table rises or lowers. Plate III shows this graphically.

PLATE II

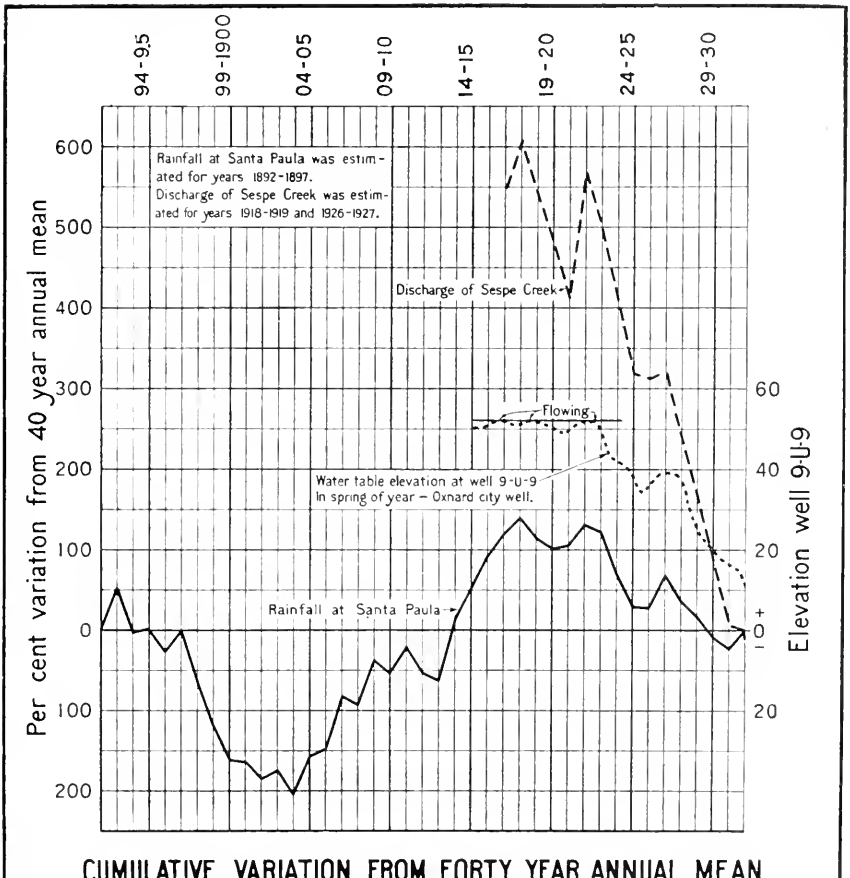


STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
LINES OF EQUAL PRECIPITATION
AVERAGE IN INCHES
1892-1932
LEGEND
DIVISION BOUNDARIES
WATERSHED BOUNDARIES
MOUNTAIN AREA BOUNDARIES
RAINFALL STATIONS
SCALE
MILES
CENTRAL DIVISION
SOUTHERN DIVISION
NORTHWEST DIVISION
VENTURA CO
LOS ANGELES CO
VENTURA
OJAI
SANTA PAULA
FILLMORE
BARDSDALE
PIRU
CAMULOS
CASTAIC JCT
SAUGUS
NEWHALL
DRY CANYON RES
SANTA SUSANA
SIMI
MOORPARK
SOMIS
CAMARILLO
SATICOY
EL RIO
MONTALVO
OXNARD
HUENEME
OCEAN

The period of record prior to 1893 was a wet cycle, from 1893 to 1904 a dry cycle, from 1905 to 1918 a wet cycle and from 1919 to date a dry cycle. The steepness of the graph of rainfall on the plate indicates the severity of the drought for each year and each cycle.

Whether or not there is a long-time overdraft on the underground basins the water table would fall in such a period as that since 1919. Coincident with the drought, however, there has been a large increase in irrigated area causing uncertainty as to whether the drop in the water table is due to permanent overdraft because of recent expansion or is merely temporary, due to drought, and it was to determine this, to plan a method of remedying it if it now existed and to plan for future expansion that the investigation was carried out.

PLATE III



CUMULATIVE VARIATION FROM FORTY YEAR ANNUAL MEAN

The various divisions or basins into which the area was divided for study are as follows:

Santa Clara River Valley—

Eastern Basin (mostly in Los Angeles County).
Piru Basin.
Fillmore Basin.
Santa Paula Basin.

Coastal Plain—

Montalvo Basin (nonpressure).
Oxnard Plain (pressure area).
West Las Posas Basin.

Ventura River Valley—

Ojai Valley.
Coyote Valley.
Upper Ventura River Valley.

Calleguas Creek Valley—

Simi Valley.
Las Posas Valley (Moorpark-Somis).
Santa Rosa Valley.
Pleasant Valley.

Conditions are somewhat different in each of these and conclusions as to water supply are set out separately in the following.

Conclusions as to Water Supply

In the Eastern Basin, rainfall is small and the recent alluvium of the basin is shallow. Climate is such that type of crop which can be raised does not justify large expense for water. It is believed development here will be small and that it does not constitute a threat to the water supply to the valleys down river in Ventura County.

Piru, Fillmore and Santa Paula basins have surplus water supply without conservation for present and estimated ultimate development. Even after the long period of drought now in progress the lower end of Fillmore Basin and all of Santa Paula Basin are so full that the underground water is forced to the surface along the river channel and a growth of willows is sustained which is estimated to be wasting over 12,000 acre-feet of water each year. The water table in Piru Basin lowers drastically in periods of drought but the basin will fill with normal years of precipitation. In the other two basins only moderate lowering of the water table occurs in dry cycles.

The Coastal Plain derives its natural supply from overflow of water which has percolated into Santa Clara River Valley and also from percolation of floods crossing Montalvo Basin. As development increases in the valley, supply to the plain decreases. There is thought to be a small long-time shortage in the Coastal Plain with present draft and if there had been the same acreage irrigated in Santa Clara River Valley and the plain during the past forty years as there is today, and if the pumping draft per acre had been the same as during the period of investigation, the water table in the plain would now be

considerably below sea level. This condition threatens intrusion of water from the ocean into the pumping strata. Further development in Santa Clara River Valley and in the plain will increase danger from this source. It is probable, however, that for the present type of crops in the Coastal Plain the pumping draft would be less in years of normal or above normal rainfall than the average during the five years of field work and if so the overdraft predicated on present draft would not actually exist. However, intrusion of salt water would still threaten.

In Ojai Valley the natural underground supply is believed to average more than sufficient for present draft on it and if supplemented by spreading on the cone to induce artificial recharge of the basin, it is believed the supply will be sufficient for a considerable increase in draft. Fluctuations in water table with wet and dry cycles are drastic but when the water table is high there is waste by seepage out of the gravels. When it is low this ceases and becomes available for pumping.

For the basin along the upper Ventura River, information, although all available was gathered, is not sufficient to draw as definite conclusions as for the basins previously discussed. Agricultural draft on the basin is small. The city of Ventura draws most of its supply at the lower end from overflow of the ground water of the basin. There is no indication that the basin could not safely furnish a larger supply than at present by proper development.

The underground waters of the valleys of Calleguas Creek are apparently derived in the main from deep percolation of rain on the porous portions of the watershed, which is transmitted underground to the valleys. No attempt has been made to evaluate this supply and hence no evaluation is made of the total supply. Conclusions made are indefinite and based mainly on behavior of the water table during the investigation and the area of permeable watershed tributary to each valley.

Around Simi Valley the watershed to the north is not permeable but it is to the south. The long-time average supply to the north side of the valley floor may be insufficient for present draft but it may be sufficient to the south side.

The watershed of Las Posas Valley is large on the north side and highly permeable. The long-time average underground supply is believed sufficient for present draft and probably for additional draft.

The watershed of Santa Rosa Valley on the south is permeable. No evidence was found leading to the belief that a shortage in supply exists but no estimate is attempted of additional draft which may be made. The water table stays at a remarkably constant level whether the seasons are wet or dry.

Pleasant Valley has no large watershed nor is it very permeable. The water table is under pressure over part of the valley and no contribution could occur from rainfall in this area. Most of the wells penetrate below the recent alluvium into the Saugus formation and draw their supply from it. It is believed the water supply is inadequate for present development.

With the exception of Ventura city and the possibility of intrusion of salt water in Oxnard Plain the situation as to water supply does not call for immediate expenditure to remedy it in any of the basins even

though shortage may exist in some. While a shortage may exist in some of the valleys of Calleguas Creek Basin yet the water table can go to considerably greater depths than at present before imported water could compete in cost, even with greater pumping lift.

Although water supply is believed sufficient in most of the county, yet when the water table lowers, quality of water deteriorates and expenditure for conservation may be justified for this where it can be done cheaply as in the case with the proposed Piru spreading works.

DEVELOPMENT PLANS

Santa Clara Valley and Calleguas Creek Basin

Numerous reservoir sites exist on Piru and Sespe Creeks tributary to Santa Clara River, as shown on frontispiece. The estimated average annual run-off of these creeks for the forty-year period beginning fall 1892 is 53,000 acre-feet and 94,000 acre-feet, respectively. Several sites exist in Calleguas Creek Basin but the average local run-off tributary to them is insignificant. Estimates of cost of reservoirs were made for Los Alamos, Spring Creek, Blue Point and Devil Canyon sites on Piru Creek, of Cold Spring and Topa Topa sites on Sespe Creek and of Camarillo site on Conejo Creek tributary to Calleguas Creek. The last would be used to conserve winter run-off of Santa Clara River conveyed to it by conduit. Estimates were made for various capacities and various types of dams on the Sespe and Piru Creek sites. There may be other reservoir sites, particularly on Piru Creek in the canyon below Spring Creek, not found during the investigation and a careful reconnaissance should be made prior to any construction program.

The sites mentioned are believed to be the cheapest possibilities but the costs as shown by these estimates are excessive. The run-off is extremely erratic, that of the maximum year being over forty times that of the minimum year while for the ten-year period 1923–1932 it is estimated to be only 60 per cent of the long-time average. The waste into the ocean for the ten-year period is estimated to be only about one-third the long-time average. This, together with the excessive cost of reservoirs, indicates that if built they should be built to control only the waste of the deficient periods of years as it would be prohibitive to attempt to hold over water in them from the years of excess run-off, and studies indicate that all underground reservoir capacity in Santa Clara River Valley will be fully occupied by natural percolation in wet cycles. This may be true also of Oxnard Plain even without conservation but spreading at Montalvo will assure it. No other area is naturally accessible and the valley material east of Oxnard Plain is not suitable for spreading to recharge the underground reservoirs even if space were available in wet cycles. Accordingly the studies of reservoir capacity and yield are based on the salvage possible in the ten-year period, plus the holdover from the winter of 1921–22, as the reservoirs would be filled in that year of prolific run-off.

Studies were also made of conservation which could be accomplished by utilizing space in the underground reservoirs of Piru Basin in Santa Clara River Valley and Montalvo Basin in the Coastal Plain. In these basins the water table lowers sufficiently in dry cycles so that more water could be caused to percolate into them. Piru Basin,

it is estimated, will naturally refill in wet cycles so that no more water could be placed in it at such times but this would not be the case with Montalvo Basin unless, as seems probable, the draft during wet cycles were smaller than found in the years in which the investigation was in progress.

Spreading grounds are proposed in these two basins to cause water which now wastes into the ocean during floods to percolate to the water table. Estimated cost and accomplishment are as follows, the amount of salvage being that in excess of natural percolation:

TABLE 2

COST AND ACCOMPLISHMENT OF SPREADING WORKS, SANTA CLARA VALLEY AND COASTAL PLAIN

Name	Average conservation 1922–1932, acre-feet Diversion rate 200 sec. ft.	Estimated cost	
		Total	Per acre-foot conservation
Piru	4,800	$401,000	$84
Montalvo	12,600	348,000	28

A cheaper plan could be worked out at each location. The diversion rate in each case would be smaller and the salvage less. The cost per acre-foot would be less.

Estimated salvage by surface reservoirs in the following table is from stream flow which would still run into the ocean after supplying the above spreading works, natural percolation and present diversions. The release would be regulated so that it could be caused to percolate into the spreading grounds listed in the foregoing table.

TABLE 3

COMPARATIVE COST OF CONSERVATION BY RESERVOIRS BASED ON TYPE OF DAM FOUND CHEAPEST AT EACH SITE

SPREADING WORKS BUILT

Name	Approximately most economic capacity, acre-feet	Average conservation 1922–1932, acre-feet*	Cost	
			Total	Per acre-foot conservation
Piru Creek—				
Los Alamos	11,600	**3,000	**$1,710,000	$570
Spring Creek	15,000	3,470	1,550,000	455
Blue Point	20,000	4,800	3,500,000	730
Devil Canyon	30,000	5,770	3,600,000	625
Sespe Creek—				
Cold Spring	40,000	8,600	1,920,000	224
Topa Topa	40,000	16,400	3,860,000	366

* The ten-year period plus a full reservoir from the winter of 1921–22.
** Includes Liebre Creek diversion to the reservoir.

The following table gives for the most important surface reservoirs, for which estimates were made, the estimated salvage and cost per acre-foot assuming no spreading works are built and that all conservation

is credited to the reservoirs. From them water would be released in flows small enough so that it would percolate in the stream bed.

TABLE 3-A

COMPARATIVE COST OF CONSERVATION BY RESERVOIRS

SPREADING WORKS NOT BUILT

Name	Acre-feet		Cost	
	Capacity	Average conservation 1922-1932	Total	Per acre-foot of conservation
Piru Creek—				
Spring Creek	15,000	4,900	$1,550,000	$316
Devil Canyon	30,000	9,170	3,600,000	392
Sespe Creek—				
Cold Spring	40,000	11,500	1,920,000	167
Topa Topa	20,000			
and				
Cold Spring	40,000			
	60,000	22,000	$5,780,000	$263

The three foregoing tables show clearly the comparative cost of conservation (1) by spreading works alone, (2) by surface reservoirs alone from which water could be released to percolate into the stream bed as rapidly as it naturally would, and (3) by a combination of surface reservoirs and spreading works. The cheapest conservation by spreading works alone would be at Montalvo where an average of 12,600 acre-feet could be conserved annually at a total capital cost of $348,000 and an acre-foot cost of $28 for the capacity of works on which estimates are based. The cheapest conservation by surface reservoirs alone would be at Cold Spring site on Sespe Creek where for the most economic capacity an average of 11,500 acre-feet could be conserved annually at a total capital cost of $1,550,000 and an acre-foot cost of $167. The combination of surface reservoir and spreading works would not give the sum of the quantities credited to each one singly since some of the water could be conserved at either. Cold Spring reservoir and Montalvo spreading works are the cheapest combination and would give for the most economic capacity of reservoir and the capacity of works on which estimates are based an average of 21,200 acre-feet annually at a total capital cost of $2,270,000 and an acre-foot cost of $107.

While the three tables show the much smaller capital cost of spreading works as compared to the cheapest surface reservoir possibility, they do not show the merits of the surface reservoirs compared one with another. The cost per acre-foot of conservation is given in each case in Table 3 for the *most economic capacity* of each reservoir and there are large differences in the amounts of conservation achieved by the most economic capacity of each, so that in Table 3, reservoirs of different capacities and different conservation achievement are compared. This may not be the best basis for comparison. At all sites except Devil Canyon* the cost per acre-foot of conservation increases

*Because of bad foundation conditions which limit the height of the dam, no estimates were made of costs of higher dams at Blue Point site and the most economic capacity is not known. Hence the discussion does not apply to Blue Point site.

rapidly for smaller or larger reservoirs than the most economic capacity. (See pages 182 and 186 giving comparative curves.) At Devil Canyon the cost per acre-foot of conservation is greater for smaller reservoir capacity, but for larger than the 30,000 acre-foot capacity shown in the table is somewhat less than the cost for that capacity.

The cheapest combination of reservoirs on Piru Creek can not be taken from Table 3 or the curves. Devil Canyon and Spring Creek together aggregate 45,000 acre-feet in capacity in that table but the conservation if both were built would not be the sum of the conservation credited to each in Table 3 because Spring Creek would control a part of the water credited to Devil Canyon. The total combined conservation would approximate 7000 acre-feet instead of 9240 acre-feet, the sum of the conservation credited to each in the table.

Since this is the case probably the most valid comparison of cost of conservation at the different surface reservoir sites is obtained by selecting some definite amount which it is desired to conserve and making the comparison on that basis. Reference to the curves above mentioned shows that *any* amount of conservation within limits which would probably be attempted can be secured very much more cheaply per acre-foot at Cold Spring site than at any other site whether on Piru or Sespe Creek and that the next cheapest location is Topa Topa site. These curves also show that when more than 4200 acre-feet are to be conserved on Piru Creek it can be secured more cheaply at Devil Canyon than at Los Alamos and when more than 5200 acre-feet are to be conserved it can be secured more cheaply at Devil Canyon than at either Spring Creek or Los Alamos. For smaller amounts the relative smallest cost is at Spring Creek with Los Alamos next and Devil Canyon last.

The following table taken from the curves, exterpolated where necessary, shows the approximate comparative costs and capacities required to conserve 6000 acre-feet during a period such as 1922–1932 at a surface reservoir to be operated in conjunction with spreading works of 200 second-foot capacity. For conservation of 3000 acre-feet the comparative costs on Piru Creek would be entirely different, indicating that selection of amount to be conserved should precede selection of the most economic reservoir on that creek.

TABLE 3-B

COMPARATIVE COST OF CONSERVATION OF 6000 ACRE-FEET AT RESERVOIRS INVESTIGATED—SPREADING WORKS GIVEN PRIORITY

Name	Approximate cost per acre-foot of conservation
Piru Creek—	
Los Alamos	*$1,020
Spring Creek	*810
Blue Point	No estimate
Devil Canyon	615
Sespe Creek—	
Cold Spring	260
Topa Topa	490

* It is probable that for both Spring Creek and Los Alamos sites the dam would have to be changed to a different type than that on which the above costs are based to make safe for the height required and that the cost per acre-foot would be greater.

It is apparent from study of the foregoing tables and the curves on pages 182 and 186 that surface reservoirs and particularly those on Piru Creek are so extremely expensive that consideration should be given to spreading works and other methods of utilizing the natural underground reservoirs prior to construction of reservoirs.

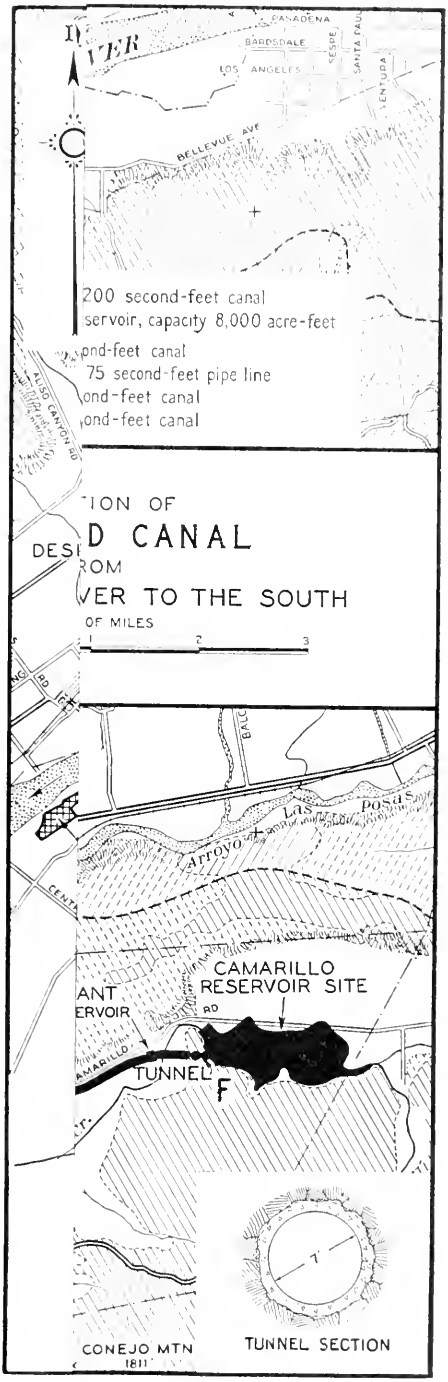
As shortage is present or may occur only in Oxnard Plain and in certain Calleguas Creek Basins and as no shortage would occur in Santa Clara River Valley during a forty-year period such as that under consideration a plan of development to provide for such a period involves transporting the surplus from Santa Clara River Valley southerly to the above mentioned areas. Two routes were considered. One would cross South Mountain south of the town of Fillmore. This would involve heavy pumping lifts, pressure pipe lines and tunnels and was discarded without making estimates of cost. The other would divert water from Santa Clara River near the western end of South Mountain. In this location one plan considered was a 200 second-foot conduit which would skirt the mountain and end in the proposed Camarillo reservoir of 8240 acre-feet capacity on Conejo Creek, for which the naturally tributary supply is negligible. A conduit diverting at this point would take the surplus of Santa Clara River Valley *after* it leaves the valley. A branch conduit may also be necessary to convey water to the south end of Oxnard Plain but for most of it, it is necessary only to place the water underground in Montalvo Basin, whence it will travel to the place of use through underground aquifers. It may be found that it will reach the entire basin in this way.

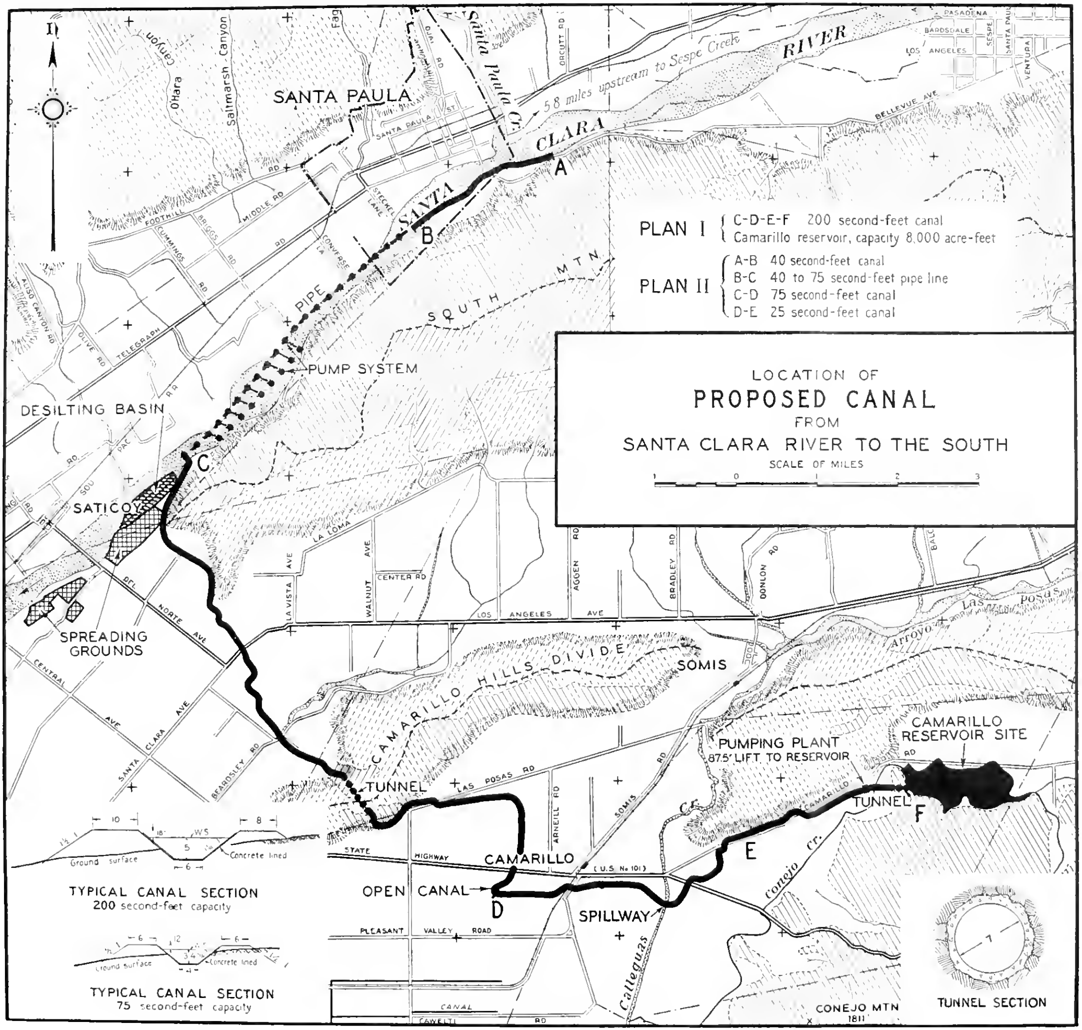
A feature unfavorable to surface reservoirs on Piru Creek is the difficulty in getting the water conserved to the point of diversion to the Coastal Plain and areas south. A pipe line or other type of conduit approximately 25 miles in length would be required to bring Piru Creek water to the point of diversion around South Mountain because a considerable part of the water conserved in the dry cycle and allowed to sink in Piru Basin would probably not reach the Montalvo diversion until the wet cycle had begun and the basins were full to overflowing without surface reservoir conservation.

Pumping in Santa Paula Basin

In view of the excessive cost of surface reservoir capacity, consideration was given to pumping in lower Santa Paula Basin. This would create additional underground reservoir capacity and conserve water by killing the willows now growing there, thus making a large part of the present annual waste of 12,000 acre-feet available for use. Flood water would also be conserved by percolation, either natural or induced, into the space thus provided. In the plan on which cost estimate was made the water thus conserved would be conveyed to the eastern end of Pleasant Valley by a 75 second-foot conduit. Its location would be the same as the 200 second-foot conduit above and is shown on Plate IV. Camarillo Reservoir would not be necessary.

Comparative total cost of two projects for conveying 12,000 acre-feet of water south around the end of South Mountain is as follows:


PASADENA
BARDSDALE
LOS ANGELES
SESPE
SANTA PAULA
VENTURA
BELLEVUE AVE
200 second-feet canal
servoir, capacity 8,000 acre-feet
ond-feet canal
75 second-feet pipe line
ond-feet canal
ond-feet canal
ALISO CANYON RD
DES
TION OF
D CANAL
ROM
VER TO THE SOUTH
OF MILES
1
2
3
BALC
Arroyo
Las
Posas
CAMARILLO
RESERVOIR SITE
ANT
ERVOIR
RD
CAMARILLO
TUNNEL
F
7'
CONEJO MTN
1811'
TUNNEL SECTION


LOCATION OF
PROPOSED CANAL
FROM
SANTA CLARA RIVER TO THE SOUTH
SCALE OF MILES
PLAN I { C-D-E-F 200 second-feet canal
Camarillo reservoir, capacity 8,000 acre-feet
PLAN II { A-B 40 second-feet canal
B-C 40 to 75 second-feet pipe line
C-D 75 second-feet canal
D-E 25 second-feet canal
SANTA PAULA
SANTA CLARA RIVER
5.8 miles upstream to Sespe Creek
Santa Paula Cr.
SOUTH MTN
PIPE
PUMP SYSTEM
DESILTING BASIN
SATICOY
SPREADING GROUNDS
CAMARILLO HILLS DIVIDE
SOMIS
PUMPING PLANT
87.5' LIFT TO RESERVOIR
CAMARILLO RESERVOIR SITE
TUNNEL
CAMARILLO
OPEN CANAL
SPILLWAY
Arroyo Las Posas
Conejo Cr.
Calleguas Cr.
CONEJO MTN 1811
TYPICAL CANAL SECTION
200 second-feet capacity
Ground surface
Concrete lined
TYPICAL CANAL SECTION
75 second-feet capacity
TUNNEL SECTION

PLAN 1. SURFACE RESERVOIRS

Cold Spring Reservoir (conservation 8600 acre-feet)	$1,920,000
Conduit of 200 second-feet capacity, diverting floods to Camarillo Reservoir when spreading works not operated (conservation 3400 acre-feet) and delivery from Cold Spring Reservoir direct to irrigated lands in years when available	1,300,000
Camarillo Reservoir	808,000
Total	$4,028,000

PLAN 2. UNDERGROUND RESERVOIRS

Created by Pumping

(See Plate IV)

Gravity diversion of rising water and pumping plant installation in lower end of Santa Clara Valley (conservation 12,000 acre-feet at least)	$371,000
Conduit of 75 second-feet delivering water by gravity to Pleasant Valley lands in all years	583,000
Camarillo Reservoir (not required)	-------
Total	$954,000

Either of these plans could be used to deliver water by further pumping to Las Posas Valley. The comparison indicates that it would cost about four times as much to conserve 12,000 acre-feet by surface reservoirs as it would by creating new underground capacity in Santa Clara River Valley. Operating cost, however, would be higher for the latter, but not sufficiently higher to cause total annual cost of Plan 2 to approach that of Plan 1.

The above two plans are independent of the spreading works noted in Table 2, but Plan 2 would decrease the water available to spreading works at Montalvo.

Conclusions—Santa Clara River Valley, Calleguas Creek Valley and Oxnard Plain

The cheapest step in conservation of Santa Clara River Valley water would be construction of Montalvo spreading works. The next would be a pumping project in Santa Paula Basin and a conduit of 50 to 100 second-foot capacity to Pleasant Valley if investigation indicates that legal complications can be overcome. For present draft Montalvo spreading works would prevent marine intrusion into the pumping strata of Oxnard Plain with considerable margin of safety. Piru spreading works would raise the water table in Santa Clara River Valley and help the quality of water. They would benefit the possible future shortage in Oxnard Plain to an extent.

Nothing more than the spreading works is believed necessary at present if their accomplishment is found to be as estimated but when and if the time arrives that water must be taken south, the size of the conduit and the comparative merits of creating additional underground storage space by pumping or creating surface storage space by construction of a dam should be reviewed in the light of new information which will have been gained both as to the silt problem and other matters.

When and if construction of reservoirs is undertaken, Cold Spring would be the first on the list because cheapest and Topa Topa would be next unless reconnaissance finds cheaper sites than those investigated.

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When and if construction of reservoirs is undertaken, Cold Spring would be the first on the list because cheapest and Topa Topa would be next unless reconnaissance finds cheaper sites than those investigated.

Spreading works and utilization of Santa Paula Basin would provide during a period such as 1922–1932 an average of about 25,000 acre-feet annually of new water or perhaps more and it is possible by reservoir construction to provide about 25,000 acre-feet in addition during such a period bringing the total possible salvage to at least 50,000 acre-feet.

Silt Problem. The expense of coping with silt is an intangible item not considered in the foregoing costs. Silt disposal is a serious problem in an attempt to conserve the waters of Ventura County as shown by the large amount of silt in water samples from streams collected by Santa Clara Conservation District. The comparative difficulties of the three available methods of conservation appear about as follows:

1. Natural silt disposal would not be upset by pumping Santa Paula Basin and creating new storage capacity. The additional expense would therefore be nothing.

2. The spreading works proposed are designed to provide for disposal of silt from the works to the stream bed whence it would find its way to the sea in subsequent floods. An item of additional expense would be incurred.

3. No way is known of disposing of silt from surface reservoirs. Unless such means are found it would finally fill the reservoirs and destroy the investment. In proper accounting an amortization charge would be set up to care for this in addition to the amortization charge to retire the debt incurred by building the reservoir. Because of the large cost of the reservoirs it is believed such charge for silt depreciation alone would be larger than annual expense of clearing silt from spreading works to say nothing of interest charge and the other amortization charge just referred to.

Ventura River Basin

Two reservoir sites were investigated, the most economic capacities of which are as follows:

TABLE 4

CONSERVATION BY RESERVOIRS, VENTURA RIVER BASIN

Name	Location	Approximately most economic capacity, acre-feet	Average conservation 1922–1932, acre-feet	Cost	
				Total	Per acre-foot of conservation
Dunshee	Coyote Creek	7,400	2,000	*$780,000	$390
Matilija	Ventura River	10,000	5,300	2,550,000	481

*Includes conduit for diversion of Santa Ana Creek to reservoir.

The cost of a 25 second-foot conduit from Matilija Reservoir to Ojai Valley is estimated at $215,000.

Conclusions—Ventura River Basin

No construction is absolutely necessary at present for Ojai Valley but spreading works on the cones of the creeks tributary to it would

raise the water table. Importation of water from Ventura River or Sespe Creek would involve such large cost that it seems impossible.

The yield of the upper Ventura River Basin could probably be improved by pumping the basin and installing spreading works. The estimated cost of spreading works is $142,000. No estimate of amounts of yield from the basin has been made. Before either installation of pumps or of spreading works the basin should be explored to determine capacity and depth to water table and the matter should be reviewed in the light of knowledge thus gained.

The city of Ventura has four choices in the matter of water supply: (a) development of Upper Ventura River Basin as above noted; (b) construction of Dunshee Reservoir or other reservoir on Coyote Creek;* (c) pumping in the Lower Ventura River Basin below Casitas Road and near the ocean; (d) pumping at some point in the Coastal Plain southeast of the city. Costs for all these items have not been estimated but the estimate of Dunshee Reservoir indicates the probability that it would be by far the most expensive per acre-foot delivered. The first and the last involve certain legal complications.

The silt problem previously discussed in connection with control of Santa Clara River would also be important on Ventura River and the foregoing discussion applies to it equally.

CONFLICT WITH HIGHWAY ON PIRU CREEK

The new state highway between Los Angeles and Bakersfield passes through Spring Creek and Los Alamos reservoir sites. As this is the second most important stream in Santa Clara River Basin capable of conservation by surface reservoirs, question arises as to the damage suffered by Ventura County if the highway occupancy precludes use of these sites for conservation of water.

In the estimates of cost on which the following paragraphs are based no allowance was made for removal of highway from the above reservoir sites so that the comparison is the same as though the highway were not constructed.

Spreading works at Piru and Montalvo would give cheaper conservation by far than the cheapest surface reservoir on Piru Creek. Likewise the reservoirs on Sespe Creek would be much cheaper per acre-foot of conservation than those on Piru Creek and would give a much greater amount of conservation. Furthermore, pumping in Santa Paula Basin to create additional capacity and to salvage a part of the estimated 12,000 acre-feet now being lost annually by willow growth would be cheaper than any known surface reservoir either on Piru or Sespe Creek.

The amount of conservation ultimately advisable is problematical at the time of this report. Economic limitations may be such that it will be impossible to supply all lands to the south which may eventually have a shortage in supply. It is probable that all cheaper conservation features will be adopted first and if so, no matter what the ultimate need, a reservoir on Piru Creek would be the last on the program and

* A reservoir site exists on Coyote Creek a short distance above its junction with Ventura River. No surveys had been made of this by others at the time of this report. Before construction of a reservoir on Coyote Creek this site should be surveyed and foundation explored to determine its merits compared to Dunshee.

its necessity may be far in the future. The future alone can determine whether it will ever be necessary and decision when made will rest on accumulation of knowledge between the present and the time of the decision. If decision is reached to add to conservation at that time by building reservoirs on Piru Creek and if the amount of additional conservation required is greater than an average of 5200 acre-feet annually for a period such as that on which estimates of yield are based, Devil Canyon reservoir would be cheapest. Since this is not occupied by the highway there would be in that case no conflict with its use for a reservoir.

Conclusion

No conflict may exist but in any case is distant in the future. It may never arise because (1) it may never be found economically feasible to place Piru Creek water on lands for which a local shortage has developed or on lands which may develop in the future; (2) if it is found feasible to do so it may be desirable to build a reservoir capable of conserving more than 5200 acre-feet annually in a dry cycle such as 1922–1932, and if so Devil Canyon instead of one of the sites involved in the highway location would be cheapest; (3) it may be desirable to fully develop Piru Creek and if so Devil Canyon site being near the mouth and having very large capacity gives an opportunity lacking in either Los Alamos or Spring Creek sites.

GENERAL SUMMARY OF CONCLUSIONS

For a period of years having rainfall similar to the period from 1892 to 1932 no shortage of underground water supply would exist in Santa Clara River Valley either for present irrigated area or for the possible ultimate area which may be irrigated in that valley. A small shortage may now exist in Oxnard Plain but a more serious situation may arise in that area because of possible intrusion of salt water from the ocean as the water table lowers in dry cycles of years. If spreading works of sufficient capacity are installed at Montalvo the water table would be sustained, in any dry cycle of record, at an elevation sufficient to repel salt water. If this is done the shortage, if it exists, will be amply provided for.

A shortage probably exists at present in Simi Valley and Pleasant Valley, but until the water table lowers so much that expense of pumping present supplies becomes larger than expense of importing water there is no need for such importation. In Las Posas and Santa Rosa Valleys, no evidence of deficiency of long-time average recharge is evident now.

In Ventura River Basin there is no evidence of permanent shortage in Ojai Valley or in Upper Ventura River Valley. It is believed both basins can be developed to yield a greater supply than they do at present

A plan for development of the water resources of Ventura County involves taking the surplus of Santa Clara River Valley south to Oxnard Plain and to the valleys of Calleguas Creek, and controlling the surplus of Ventura River for distribution within that valley and to the city of Ventura. This necessitates conserving the waters of both streams either by surface reservoirs or by better utilization of the

underground reservoirs, which rainfall in the valley and the streams entering the valley now recharge by natural percolation, or by a combination of both.

The cost of surface reservoirs would be inordinately high but investigation shows that in Santa Clara River Valley the underground reservoirs can be much better utilized than they are at present and the water thus conserved conveyed southward at a reasonable cost. The water table in Santa Clara River Valley is so high that even after several years of drought almost 3700 acres of willows are growing in the river bottom and it is estimated that these are wasting over 12,000 acre-feet per year. At the same time near Piru, upstream from the willows, the water table is about 150 feet below the surface and at Montalvo, downstream from the willows, sufficient underground water is not coming from Santa Clara River Valley to maintain water level in Oxnard Plain at sufficient elevation. The willows are wasting about 40 per cent as much water as is being beneficially consumed in the valley.

Oxnard Plain can be guarded against danger even with considerable increase in pumping by spreading the flood flows of the river near Montalvo as proposed in this report and causing additional percolation into Montalvo Basin whence natural underground aquifers would convey it southward possibly to all parts of the plain. The water table in Piru Basin can be sustained by spreading water in that basin and this would in part be available to the entire Santa Clara Valley and to Oxnard Plain. Both of these items can be done at comparatively small cost.

The cheapest next step in development would be to pump from the lower end of Santa Clara River Valley and convey the water thus made available southward if legal complications can be overcome. This appears worthy of exhaustive consideration at the time additional water is needed. If experience demonstrated the success of this and as more water became necessary the pumping could be increased. This would salvage the waste by willows and would create a new underground reservoir into which the floods of the river would percolate, thereby salvaging additional water. The limitations of this should be thoroughly explored before recourse to surface reservoirs. The silt problem makes conservation in this way especially desirable. If recourse must be had to surface reservoirs those on Sespe Creek offer the most favorable possibilities.

In Ventura River Basin the limited underground capacity makes necessary the construction of surface reservoirs if the supply from that basin is to be increased to provide for perhaps 50 per cent more than present draft. Whether such construction will be considered in the near future depends on the decision of Ventura city as to other possibilities.

NOTE.—Detail data gathered during the investigation are not published in this bulletin, but have been assembled in a separate mimeographed bulletin, No. 46-A, which contains,

1. Precipitation Records.
2. Measurements at Wells.
3. Stream Measurements.
4. Analysis of Quality of Water.
5. Crop Survey.

CHAPTER II

GENERAL DESCRIPTION

Ventura County is one of the counties of southern California, lying along the coast between Los Angeles and Santa Barbara counties. Its total population of 54,976 * is entirely concentrated in the arable areas. Buenaventura or Ventura as it is usually called, the county seat, with a population of 11,603, is supported largely by the oil industry; Santa Paula with a population of 7452, and Fillmore with a population of 2893, are the principal towns of the citrus area; Oxnard with a population of 6285 is the center of the beet sugar industry; and Ojai with a population of 1468 is the principal town of Ventura River Basin. There are also many small unincorporated settlements.

The stream systems of the northern and southern parts of the county drain into the ocean in valleys of either Santa Barbara or Los Angeles counties and are not part of the water supplies of Ventura County, hence this report deals only with the basins of Ventura River, Santa Clara River and Calleguas Creek systems all of which contribute to the alluvial plains of the county. The total area studied comprises 2230 square miles of which 1785 square miles are mountainous, 109 square miles are hills and foothills classified as irrigable or habitable, and 336 square miles are valley floor. (See frontispiece.) These three streams after flowing through alluvial valleys finally debouch upon the flat featureless coastal plain of the county, the major portion of which is called the Oxnard Plain. Ventura River reaches the coastal plain at its extreme north end and contributes practically nothing to its water supply so that it may be considered a separate stream system. Santa Clara River and Calleguas Creek both enter the main area of the plain and the areas depending on the underground water contributed by each can not be delimited.

Rainfall is scanty. It averages twelve inches at Oxnard, seventeen inches at Piru, seventeen and five-tenths inches at Ojai and thirteen inches at Santa Susana. (See Plate II.) In the mountains it varies from nine inches to thirty inches, with some snow at higher elevations which quickly melts. There are two seasons, wet and dry, with 78 per cent of the precipitation occurring from December to March, inclusive. Beans and deciduous trees bear without irrigation but production is much increased if these crops are irrigated. Other crops require it. Most of the irrigation supplies are procured by wells sunk into the alluviums of the valley fill, but in the Santa Clara River system and Ventura River system there is a small summer discharge which is diverted for gravity irrigation.

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* Population statistics from 1930 census report.

Santa Clara River

The drainage area of Santa Clara River may be subdivided as follows:

Area	*Square miles*
Eastern Santa Clara River mostly in Los Angeles County	662
Hopper Creek	23
Piru Creek	432
Sespe Creek	257
Santa Paula Creek	40
Miscellaneous areas—South	36
Miscellaneous areas—North	148
Total	1,598

The estimated annual run-off for the period 1892–1932 varies as shown below.

	Acre-feet	*Per cent of mean*
Maximum	814,000	380
Minimum	20,000	9.3
Mean	214,000	100

The only discharges of economic importance are those that percolate or can be caused to percolate or can be held in reservoirs. Construction of reservoirs at points having a material natural water supply is possible only on Piru Creek which gives 53,000 acre-feet average estimated annual discharge for the above period or 25 per cent of the total run-off of the system, and on Sespe Creek which gives 94,000 acre-feet average estimated annual discharge for the period or 44 per cent of the total. The other streams are not susceptible of control by surface reservoirs and none are possible on the main river.

Calleguas Creek

The drainage area of Calleguas Creek may be subdivided as follows:

Area	*Square miles*
Calleguas Creek proper above Somis	164
Conejo Creek drainage	64
Total	228

The run-off is small and only occasionally does water escape into the ocean. Construction of a reservoir is possible at the mouth of Santa Rosa Valley but the salvage of Conejo Creek water made possible by it is negligible. It would be used, if constructed, to impound water conveyed to it from Santa Clara River.

Ventura River

The drainage area of Ventura River may be subdivided as follows:

Area	*Square miles*
Main river above Casitas Bridge	95
Main river below Casitas Bridge	39
Coyote Creek	41
San Antonio Creek	51
Total	226

Reservoir sites exist on the main river in the mountains and on Coyote Creek.

The estimated annual run-off varies as follows for the period 1892–1932.

	Acre-feet	Per cent of mean
Maximum	250,000	417
Minimum	500	0.8
Mean	60,000	100

The main river discharge is estimated at 23,000 acre-feet for the above period or 38 per cent of the total. That of Coyote Creek is estimated at 12,400 acre-feet or 21 per cent of the total.

TABLE 5

GROWTH OF CROPPED AREA IN VENTURA COUNTY

Year	Source of information	Cropped area in acres	
		Irrigated	Non-irrigated
1909	Thirteenth Census of the United States	25,273	
1912	U. S. Department of Agriculture, Office of Experiment Stations, Bulletin 254	34,190	
1919	Fourteenth Census of the United States	31,716	
1928	Office of Ventura County Agricultural Commissioner	86,771	74,853
1929	Fifteenth Census of the United States	88,519	
1930	Office of Ventura County Agricultural Commissioner	90,463	75,079
1932	Survey by Division of Water Resources	*107,133	

* Includes area in municipalities and subdivisions. Basis for preceding estimates uncertain.

NOTE.—Detail tabulation of present cropped areas is shown on pages 220 and 221.

CHAPTER III

GEOLOGY*

In contact with the underground water basins in this area there is a great variety of rocks, both in regard to age and lithology and permeability. The formations exposed are:

- Basement Complex (pre-Jurassic)
- Chico formation (Upper Cretaceous)
- Martinez formation (Lower Eocene)
- Meganos formation (Middle Eocene)
- Tejon formation (Upper Eocene)
- Sespe formation (Oligocene ?)
- Vaqueros formation (Lower Miocene)
- Topanga formation (Middle Miocene)
- Mint Canyon formation (Upper Miocene)
- Modelo formation (Upper Miocene)
- Pico formation (Lower Pliocene)
- Saugus formation (Upper Pliocene and Lower Pleistocene)
- Terrace deposits (Pleistocene)
- Alluvium (Recent)
- Extrusive and Intrusive andesite and basalt (Miocene)

The Basement Complex, of pre-Jurassic age, consists of schist quartzite, slate and limestone, intruded by different varieties of granite. These rock types may all be considered impervious except for joints or solution cavities. Water rising in areas of the Basement Complex is of good quality. The Basement Complex crops out in the extreme eastern end of the area, where it has been elevated and brought into contact with younger formations by faulting.

The Chico formation (Upper Cretaceous) crops out in the Simi Hills to the east and south of Simi Valley. It consists essentially of massive brown sandstone with thin streaks of shale. No water wells are known in the Chico formation. The sandstone is fairly well cemented.

The Martinez, Meganos and Tejon formations (Lower, Middle and Upper Eocene) consist of conglomerate, sandstone and shale. They may be considered as nonwater-producing except from joints and fractures. No water wells are known in these formations. Tunnels driven into them on the north side of Ojai Valley yield some water.

The Sespe formation (Oligocene ?) is characterized by its high coloring. The formation comprises sandstone, shale and conglomerate, usually colored deep red-brown, variegated with gray, green, blue, purple and red. It is probably of nonmarine origin. It is not an important water producer. A few wells to the west of Ventura River Basin obtain small quantities of water from the Sespe formation. At the western end of Simi Valley wells drilled in the formation produced small amounts of water of very poor quality. There are a few small springs in it northeast of Moorpark.

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* Previous reports on the geology of this area include U. S. Geological Survey Bulletin No. 309, The Santa Clara Valley, Puente Hills and Los Angeles Oil Districts, by G. H. Eldridge and Ralph Arnold, 1907, and U. S. Geological Survey Bulletin No. 753, Geology and Oil Resources of part of Los Angeles and Ventura Counties, by W. S. W. Kew, 1924. Both of these Bulletins have been freely drawn upon. Mr. Claude Leach contributed to the geology in the Santa Clara Valley region. Dr. Eliot Blackwelder kindly furnished geological maps of the Ventura and Santa Paula quadrangles.

The Vaqueros formation, of Lower Miocene age, consists of sandstone, shale and conglomerate. Its permeability is low and there are no water wells in this area producing directly from it. Deep wells drilled into structural depressions in this formation would probably produce large amounts of water. A well drilled by the Shell Oil Company on an anticline near Santa Barbara developed a large quantity of water from it.

The Topanga formation (Middle Miocene) consists of sandstones and conglomerates. In the vicinity of Newbury Park where the alluvium is of small area and shallow depth the wells obtain their water indirectly from this formation, producing up to 25 miner's inches of water.

The Mint Canyon formation, of Upper Miocene age, occurs from the vicinity of Mint Canyon eastward to the San Gabriel Mountains. It consists of interbedded conglomerate, sandstone and clay. "A study of the lithologic conditions of the Mint Canyon formation indicates that it must have been deposited under subaerial conditions. The region at that time was probably a large valley surrounded by mountains composed largely of granitic and metamorphic rocks and similar to large valleys in the southern California of today."* The formation is soft and gives rise to bad land topography. In general, the sandstone and conglomerate lenses are poorly consolidated and are relatively pervious.

Many shallow water wells have been drilled into this formation and they produce small amounts of potable water. No large capacity wells are known in it. It is probable that deep wells in the formation would be good producers, especially if drilled in structural depressions.

The Modelo formation, of Upper Miocene age, consists essentially of shale, with lenses of sandstone. Any water in contact with the shale is generally of poor quality, due to salts leached from it. The Modelo formation borders the Piru Basin, and Piru Creek flows for a great part of its course through it. According to Scofield,** the salt content of the water of Piru Creek, as measured by electrical conductance, is much higher than that of Sespe Creek. No water wells are known in the Modelo formation.

In the area between Simi Valley and Newbury Park occur extrusives of andesite, basalt, dacite, tuff and breccia. The extrusives are in part vesicular and scoriaceous, and fractured. One well in Tierra Rejada, west of Simi Valley and east of Santa Rosa Valley, obtains its water directly from the igneous rocks. In the vicinity of Newbury Park some wells obtain their water indirectly from them.

The Pico formation, of Lower Pliocene age, consists of interbedded sandstones, shales and conglomerates of marine origin. No water wells are known in the Pico formation. It is for the most part well consolidated, forms bold outcrops, and appears to be practically impervious to the movement of water.

The Saugus formation, of Upper Pliocene and Lower Pleistocene age, consists of gravel, sand and silt, more or less unconsolidated. It varies greatly from place to place in lithology, degree of consolida-

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* Kew, W. S. W., Geology and Oil Resources of a part of Los Angeles and Ventura Counties, U. S. Geological Survey Bulletin 753, p. 53, 1924.

** Scofield, C. S., and Wilcox, L. V., Boron in Irrigation Waters, U. S. Department of Agriculture, Tech. Bulletin 264, p. 37, 1931.

tion and permeability. Toward the west the Saugus formation is of marine origin but it grades eastward into strata of fluviatile origin or alluvial fan deposits. "The physical characteristics are unmistakably those of an alluvial deposit, a river delta, progressively sinking."* The gravels are lenticular and have a sand matrix with little argillaceous cement. Locally, there is some calcareous cement.

In the canyons tributary to the Santa Clara River in the region from the Los Angeles-Ventura County line to a point a few miles east of Saugus there are many shallow wells drilled in the Saugus formation which furnish small amounts of potable water.

North of the city of Ventura the Shell Oil Company drilled a deep well into the Saugus formation capable of producing 200 inches of water. Many of the commercial wells in the vicinity of Camarillo and Oxnard produce from this formation. Wells of the Tapo Mutual Irrigation Company in Tapo Canyon, north of Santa Susana, also produce from it.

The terrace deposits, of late Pleistocene age, are chiefly poorly consolidated gravels and sands and clays of terrestrial origin, laid down as flood plains or alluvial fans. They all exhibit a reddish color due to oxidation. They occur as almost flat-lying remnants on ridges or sides of the valleys, as on the ridge between Dry Canyon and Haskell Canyon, and also as deposits gently sloping from the hills toward the valleys partially overlain by recent alluvium, as in the area at Saugus. Several distinct terrace levels may be seen on the eastern side of Castaic Valley north of Castaic Junction. The present terraces are the remnants of originally broader deposits.

The terrace deposits are, generally speaking, permeable, and their importance as underground reservoirs depends on the local structure. Naturally, where these deposits occur as caps on ridges they can not long hold water.

The recent alluvium is confined to the lowest portions of the valleys. It represents a recent period of deposition following the earlier period when the streams eroded their channels in the older formations. It is loose and uncemented. In the Santa Clara River Valley the alluvium is chiefly gravel, forming a broad, flat deposit in the valley bottom. The surface of the gravel is covered with gray sand, hardened in places by fine silt. Although sand predominates at the surface of the Santa Clara River bed, gravel predominates below the surface, as shown by well logs. It is probable that the surface sand is carried away by the winter floods and gravel deposited in its place. Then, as the flow subsides, sand is deposited on the gravel, and finally silt.

Most of the streams of the area are now entrenched in channels in the alluvium. This is not true throughout the length of Santa Clara River but applies chiefly to tributary streams.

West of Lang the bed of Santa Clara River is dry during most of the year, except for areas near Castaic, Piru and Santa Paula where there is rising water throughout the year which supports a dense growth of willows.

The character of the alluvium varies according to locality, from the coarse, porous sands and gravels in Santa Clara River Valley

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* Hershey, O. H., American Geologist, V. 29, pp. 359-362, 1902.

to tighter, more clayey deposits formed by tributary streams and by run-off from the sediments of the hills bordering the valley. Santa Clara River, rising in an area of granitic and metamorphic rocks, and flowing through the gravelly deposits of the Mint Canyon and Saugus formations, has deposited relatively clean, porous alluvium.

In Ojai Valley, granitic boulders are absent. The alluvium is chiefly sandstone boulders with more or less angular fragments of slaty shale.

Areal Geology

Geological maps of part of the area covered in the report have been published. The maps in U. S. Geological Survey Bulletin No. 753* cover the area to the east of the Santa Paula, Quadrangle. A sketch map of the geology of a portion of the Ventura Quadrangle is included in Volume 12 of the Bulletin of the American Association of Petroleum Geologists.**

The geologic maps (Plates LI to LIII) in rear pocket, accompanying this report, are based partly on the U. S. Geological Survey maps above noted and partly on information obtained from Dr. Eliot Blackwelder, Mr. Claude Leach and others. On these maps the formations are grouped according to their importance as water yielding formations. The groups are as follows:

(1) The Recent Alluvium, which occupies the valleys and from which most of the commercial wells obtain their water.

(2) The Terrace Deposits (Pleistocene), which are, in general, permeable, and whose importance depends on structure. Many commercial wells produce from the Terrace Deposits.

(3) The Saugus formation (Upper Pliocene and Lower Pleistocene) and the Mint Canyon formation (Upper Miocene), which produce domestic supplies from shallow wells and larger supplies from deep wells. The aquifers in this group are usually confined and the water is under pressure.

(4) All the other, less pervious, formations.

RELATION OF THE TERTIARY FORMATIONS TO THE ALLUVIAL BASINS

Eastern Basin

The large area of alluvium to the east of the Ventura-Los Angeles County line is referred to as the Eastern Basin. In this basin there is a broad area of terrace gravels bordering and in places underlying the alluvium. As the few wells in the basin are located within a narrow belt in the alluvium, there is no lateral control for estimating water levels, upon which change in storage computations depend. Hence no attempt was made to compute changes in storage in the Eastern Basin.

The alluvium and terrace gravels comprising this basin are bordered on all sides and underlain by the semipervious sediments of the Saugus and Mint Canyon formations, which are both of continental origin and are the most permeable of the sediments older than the

* Kew, W. S. W., *op. cit.*

** Cartwright, Lon D., Jr., Sedimentation of the Pico formation in the Ventura quadrangle, Calif., Am. Assoc. Petroleum Geologists, Bull., V. 12, No. 3, Jan. 1928.

terrace gravels. Both formations contain streaks and lenses of poorly consolidated sand and gravel capable or producing water of good quality. Shallow wells drilled into them yield domestic supplies of water.

The depth to water measurements made during the course of the general investigation were confined to the wells drilled in the main valley bottoms as all the commercial wells occur in them. Records of depth to water were obtained for scattered wells drilled in the Mint Canyon formation in the vicinity of Mint Canyon and Plum Canyon. These wells showed very little fluctuation of water level. Information from owners of wells drilled in the Saugus formation in the area northwest of Castaic indicated that there was very little fluctuation of water level in this formation. The stable water level over long periods of time is no doubt due to the small number of wells drilled into the Saugus and Mint Canyon formations in comparison to their large area.

As the recent alluvium and terrace gravels comprising the Eastern Basin are bordered and underlain by the semiporous Saugus and Mint Canyon formations, the important question arises: "Do these older sediments constitute an integral part of the main underground alluvial water basins?" To do so, there must be a direct conneetion between the water bearing strata of these formations with the recent alluvium, so that a lowering of the water plane in the alluvium will cause a transfer of water between them and result in a corresponding lowering of the water level in the Saugus and Mint Canyon formations. In the Eastern Basin, this transfer of water does not appear to take place. Wells in the alluvium of the Santa Clara River Valley from Mint Canyon east are pumped dry in the summer months. The wells in the Mint Canyon formation do not reflect this lowering of water level.

The water level in a well drilled on the ridge between Mint Canyon and Soledad Canyon, in the Mint Canyon formation, was, when measured, 200 feet higher than the water level in the alluvium of Soledad Canyon, only 3500 feet distant.

One element preventing direct connection of the water yielding beds of the Saugus and Mint Canyon formations with the alluvial basins is folding. The older formations are warped and dip under the alluvial basins, and impervious strata interbedded with the more pervious sands and gravels prevent migration of water into the alluvium.

In the Eastern Basin there are really two basins, first, the alluvial basin, and, second, the basin composed of Saugus and Mint Canyon sediments which borders and underlies the alluvial basin. It is possible that deep wells drilled through the alluvium, well into either the Saugus or Mint Canyon formations, and perforated only in these latter formations, would produce large quantities of water. No wells of this type are known in the Eastern Basin. Under similar geologic conditions, the well previously referred to drilled by the Shell Oil Company through the alluvium of the Ventura River a short distance north of the city of Ventura produces from the Saugus formation about 200 inches of water.

The Saugus and Mint Canyon formations undoubtedly contribute some water by underflow to many of the alluvial basins. This contribution is at a more or less constant rate throughout the year and the rate

is not appreciably increased by lowering of the water level in the alluvium.

A geologic section across the Eastern Basin is shown on Plate LIII in rear pocket.

Piru Basin

Piru Basin is in Santa Clara River Valley, embracing an area about the city of Piru. The alluvium filling the basin is thick near Piru, but thin toward the east, until shale appears in the bed of the Santa Clara River near Blue Point, approximately three miles east of Piru. The shale exposure marks the eastern end of the basin.

Piru Basin is bounded on the north by the Modelo and Pico formations. These are relatively impervious and do not contribute to the underground water in the basin. The alluvium of the basin is in contact on the south with the relatively impervious Vaqueros, Modelo and Pico formations. (See Plate LI in rear pocket.)

The western boundary of the basin is based on underground water levels, and is as shown on Plate I. The underground flow of water is retarded at the western end of the basin. The water plane to the east of the basin boundary is relatively flat, but it drops off rapidly to the west into Fillmore Basin, as shown on Plate XXXVI.

Santa Clara River Valley is narrow at the western boundary of Piru Basin, and widens to the west. The increased cross-sectional area should allow a corresponding increase in the volume of underflow and account for the steep water plane immediately to the west of the basin boundary.

All the wells in the Piru Basin are drilled in and obtain water from the alluvium. Computations of change in storage were made for the Piru Basin.

Fillmore Basin

Fillmore Basin lies in Santa Clara River Valley to the west of Piru Basin and is named from the city of Fillmore, which is near its eastern end. The alluvium of the basin is underlain by terrace deposits which are in turn underlain, in the western part of the basin, by the Saugus formation which contains streaks and lenses of pervious sands and gravels separated from each other by impervious clays and silts. The depth to the contact between the alluvium and terrace gravels is not known, nor is it important as both are water bearing and are lithologically similar. The depth to the contact of the terrace deposits with the Saugus formation is not known. As there are no great anomalies in water levels in this basin, it can not be definitely stated that no wells produce from the Saugus formation. Here again there exists a condition of one basin overlying another. (See Plate LIII in rear pocket.) As the area of intake by rainfall penetration for the Saugus formation in Fillmore Basin is confined to a narrow strip to the west of the basin in the north side of Santa Clara River Valley, the yearly contribution from the Saugus formation to the alluvium must be very small. Deep wells drilled through the alluvium into the Saugus formation would probably be smaller producers over a long period than similar wells in the eastern basin.

There is a large area of pervious terrace deposits on the north side of the basin. The northern boundary of the basin is the contact of the alluvium or terrace deposits with the impervious Pico, Modelo and Tejon formations and, near the extreme western end, with the Saugus formation. The alluvium of the basin is in contact on the south with the relatively impervious Modelo, Vaqueros and Sespe formations of Oak Ridge.

The western boundary of the basin is arbitrary and is based neither on geologic structure nor a steepening of the water plane. It approximates the eastern limit of the area of rising water which supports the dense growth of willows in the Santa Clara River east of Willard Bridge.

There is some indication of a fault extending almost due west from the south side of the valley at the Piru–Fillmore Basin boundary to well number 15-N-8 (Plate XLIX in rear pocket) about four and one-half miles to the west. The presence of the fault is indicated chiefly by water levels. Some wells to the north of this supposed fault flow.

Santa Paula Basin

Santa Paula Basin on its eastern end, adjoins Fillmore Basin. Its southern boundary is the contact of the alluvium with the relatively impervious sediments of South Mountain, namely, the Pico, Modelo, Vaqueros and Sespe formations. The northern boundary is approximately the contact of the alluvium or terrace deposits with the Saugus formation. A well drilled for the Blanchard Investment Company in Fagan Canyon, northwest of the city of Santa Paula, penetrates and draws its water from the Saugus formation, yet its water level fluctuates with the water level in the alluvium. There are not enough wells to the north of the alluvium-Saugus contact to determine how far north the water level in the Saugus formation reflects the fluctuation of water level in the alluvium. In computing the change in storage, only the area of alluvium and terrace deposits was considered.

The western basin boundary is a definite, devious line separating the higher water level of Santa Paula Basin from the lower water level of Oxnard Plain. The barrier separating these two water levels is believed to be due partially to faulting and partially to a subsurface fold in the Tertiary sediments.

The alluvium and terrace deposits of Santa Paula Basin are underlain by the Saugus formation which crops out on the northern side of the valley. (See Plate LIII in rear pocket.)

Oxnard Plain Nonpressure Area

The Oxnard Plain nonpressure area occupies the upper portion of the Santa Clara River alluvial fan. The alluvium is bounded on the north along the foothills by the Saugus formation, and by Santa Paula Basin. The eastern boundary is the eastern limit of the Santa Clara River fan and is approximately a line connecting the western end of South Mountain with the western end of Camarillo Hills. The southwestern boundary was determined by a study of the well records. Those wells the water level of which rose rapidly at the end of the pumping season were included in the pressure area. Wells, the water level of which showed no rapid rise, were included in the nonpressure area.

The Oxnard Plain nonpressure area is underlain by the Saugus formation. Anomalies in water level indicate that some of the wells obtain their water from the Saugus formation but most of the water pumped is from the alluvium. There may be a slow, steady contribution of water from the Saugus formation to the alluvium, but this quantity can not be actually measured.

Oxnard Plain Pressure Area

The Oxnard Plain pressure area occupies the Santa Clara River flood plain between the nonpressure area and the Pacific Ocean. In this area occurs perched water and deeper artesian water, separated by clay beds. The depth to the upper surface of the Saugus formation varies from zero at the western end of Camarillo Hills to approximately 1300 feet. It is not a smooth surface but shows ridges and valleys extending in a general northwest-southeast direction, governed by the structural lines of the region. Overlying the Saugus formation occur the Pleistocene and recent deposits transported chiefly by Santa Clara River and deposited under estuarine conditions. The sorting action of waves in the shallow embayment accounts for the clay beds overlying the coarser, permeable sands and gravels. Small tidal lagoons and marshes still exist along the coast.

Many of the wells in the Oxnard Plain pressure area are known to produce from the Saugus formation, although there is no great difference in water level between deeper and shallower wells. This may be due to the practice of perforating the casing to produce from both the alluvium and the underlying Saugus formation.

Simi Valley

The Simi Valley Basin occupies a depression to the south of Oak Ridge and west of the Santa Susana Mountains. The two towns of Simi and Santa Susana are located in the basin. The alluvium of the basin is, on the south and east, in contact with resistant Eocene sandstone, on the north with standstone and clay of the Sespe formation, and on the west by the Sespe formation and by Miocene extrusive and intrusive igneous rocks. (See Plate LI in rear pocket.)

There are no large streams flowing into Simi Basin. The groundwater is an accumulation over a long period of rainfall on the small watershed.

There is very little real gravel in the alluvium of Simi Valley. This is because the alluvium was derived from an area of sedimentary rocks which break down by mechanical disintegration into their constituent grains resulting in fine sand chiefly, and silt and clay. What gravel lenses there are were derived by a reworking of the gravels of the Saugus formation and the terrace deposits. A large number of wells in Simi Basin are drilled through the alluvium into the underlying Sespe or Eocene formations.

At the northwestern end of Simi Valley there is a small pressure area in the alluvium. Although the static water level is above the ground surface, the water level rapidly lowers in the wells when pumped. For instance, the water level in wells numbers 20-R-1 and 20-R-18 (see Plate XLIX in rear pocket) lowers 150 feet when pump-

ing 25 inches of water, although their static level is above the ground surface.

As shown by the rapid drawdown of wells in it, the alluvium at the lower end of the basin is very tight and there is little underflow out of the basin through it. Also, a well was drilled just south of well number 20-R-18 to a depth of 264 feet and produced no water. There is a small flow of rising water at the lower end of Simi Basin due apparently to a slow upward migration of water through the tight, clayey alluvium. Flowing wells drilled in this area may be accounted for on the theory that they allow the water to reach its static level without having to overcome the friction of the alluvium.

The channel leading out of Simi Valley varies from 65 to 85 feet in depth and well logs show that a shallow lake existed at the lower end. This lake was gradually filled with vegetation and covered with silt and clay. Water evaporating from this marshy area resulted in a concentration of salts, so that the water in wells in the lower end of Simi Valley is of very poor quality. Evaporation of rising water is still increasing the mineral concentration, and there is not enough surface flow or underflow to wash this concentration out of the tight alluvium.

In general, ground water on the south side of Simi Valley is of good quality and is better than that on the north side of the valley. Water entering the basin from the south flows over and through crevices in the cemented Eocene rocks and does not pick up enough minerals from the rocks to seriously affect the water. The small streams which enter Simi Valley from the north rise in areas of Modelo shale or the Sespe formation, and leach out salts from them, chiefly from the former. Also, there are a number of old oil wells to the north of Simi Basin and it is believed that waste water from these wells is a contributing factor to the poorer quality of water on the north side of the valley.

In the Sespe formation exposed on the north side of Simi Valley there are some springs of good quality water north of the oil wells. The springs south and west of the oil wells, and down the slope from them, are of poor quality. These wells are producing highly mineralized water which eventually finds its way into the alluvium. This oil well waste water accounts for the extremely bad water in well number 19-Q-2.

North of Santa Susana, in Tapo Canyon, several wells of the Tapo Mutual Water Company are producing directly from the Saugus formation. The water contains some sulphur but is of good quality for irrigation. Here the controlling factor is structure. Plate LIII in rear pocket shows a geologic section up Tapo Canyon across the synclinal structure in which the underground water is stored.

Many of the wells in Simi Valley produce from the Tertiary sediments which underlie the alluvium in which the water is under pressure. The actual change in storage for such wells takes place around the margins of the basin outside of the alluvium.

Las Posas Valley

The Las Posas Valley extends from a line connecting the western end of South Mountain with the western end of the Camarillo Hills to the lower end of Simi Valley. As the groundwater conditions are

different in the eastern half of the valley than in the western half, the two sections will be discussed separately.

The eastern half of the valley, from the vicinity of Somis east to Moorpark, is an area of alluvium underlain by terrace deposits which are in turn underlain by the Saugus formation. Wells drilled in this area produce from all of these formations. The quality of the water is in general far better than the water at the lower end of Simi Valley. The water is obtained by underflow from the large area of terrace deposits and pervious Saugus gravels to the north. The eastern half of Las Posas Valley occupies a structural trough, as shown on Plate LIII in rear pocket.

The western half of Las Posas Valley, namely, the area between Camarillo Hills and South Mountain is also an area of alluvium, terrace deposits and Saugus formation, but these formations in this area are tight.

North of the eastern half of Las Posas Valley, in the vicinity of Epworth, there are several wells of good quality water and good rate of production. These wells are drilled in the terrace deposits and Saugus formation, which in this area, is very pervious. Good exposures of loose porous sands and gravels of the Saugus formation may be seen along the Grimes Canyon Road northwest of Epworth. (See Plate LI in rear pocket.)

The recharge for the Epworth area is dependent on the penetration of rainfall on the large area of pervious sands and gravels of the terrace deposits and Saugus formation.

Pleasant Valley

Pleasant Valley lies south of Camarillo Hills, north of the Santa Monica Mountains and to the northeast of the Oxnard Plain pressure area. Well logs in this area show that there is very little gravel in the upper 400 feet. Wells vary from 400 to 1500 feet in depth. The water is under pressure and different wells exhibit different water levels. The production is chiefly from the Saugus formation.

Santa Rosa Valley

Santa Rosa Valley lies just south of the Las Posas Hills. It is a valley of alluvium and terrace deposits bordered on the south by igneous extrusives and intrusives. The alluvium and terrace deposits are underlain by a few hundred feet of the Saugus formation which is, in turn, underlain by the Sespe formation. Wells drilled in the alluvium and terrace deposits are very good, producing up to 150 inches of water of good quality, and the water level holds up remarkably well. There is no large surface inflow of water to the basin and it obtains its recharge by rainfall penetration on the alluvium and terrace deposits within the basin and by underflow chiefly from the igneous rocks to the south. That these andesitic breccias and scoriaceous and fractured basalt are pervious is shown by a well drilled in Tierra Rejada, to the east of Santa Rosa Valley. This well was drilled to a depth of 400 feet, practically all of which was through the "Malapai formation full of wormholes," which is the vesicular and scoriaceous andesite and basalt. No gravel was encountered. The well produces about 80 inches of good water.

A well was drilled into the Saugus formation near the north side of Santa Rosa Valley, but it is a very small producer.

Although the water in the alluvium and terrace deposits is obtained by underflow from the adjoining Saugus formation and the igneous rocks, wells drilled in the alluvium and terrace deposits are more copious producers than wells drilled in the adjoining Tertiary rocks, because of the higher permeability in the more recent terrace gravels and alluvium.

Newbury Park Area

The Newbury Park area occupies depressions on the north slope of the Santa Monica Mountains south of Santa Rosa and Pleasant Valleys. Here the areal extent and depth of the Quaternary deposits is small. The water is obtained directly or indirectly from the Topanga sandstone and the igneous rocks of the area. The recharge is entirely dependent on rainfall penetration and the water level rises slowly in the winter. The wells pump down quickly; at the start they pump about 80 inches, but as the small storage in the alluvium is quickly depleted the wells settle down to a production of up to 35 inches.

Ojai Valley

The Ojai Valley Basin occupies an intermontaine depression between the Santa Ynez Mountains on the north and Sulphur Mountain on the south. The mountains which border the basin are composed of Eocene, Oligocene and Miocene sediments which are practically impervious. (See Plate LI in rear pocket.) The streams debouching from these mountains have built up steep alluvial cones, composed of very large boulders near the mountains and grading off to silt and clay at the southwestern end of the basin, where the excess water flows down San Antonio Creek to the Ventura River. The water table is likewise steep, but not so steep as the ground surface.

Some water held in crevices in the Eocene rocks on the north side of Ojai Valley is yielded to tunnels driven in the mountains.

Upper Ventura River Valley

The Upper Ventura River Valley occupies a narrow strip along the Ventura River west of Ojai Valley, confined to the alluvium. The terrace deposits which occur east and west of the basin are fairly permeable, but they are shallow in depth and offer little storage space for water. Practically their whole vertical section is exposed in the cliff to the east of Ventura River. Almost impervious Tertiary sediments crop out at several places on both sides of the alluvium and underlying the terrace deposits. (See Plate LII in rear pocket.) Springs occur along the contact of the terrace deposits with the underlying Tertiary sediments.

The north end of the basin is the point where Ventura River emerges from its canyon in the Santa Ynez Mountains. The south end of the basin is at La Crosse, where the Modelo (Miocene) shales form a barrier and cause the underground water to rise to the surface.

CHAPTER IV

HYDROLOGY

Practically all water supplies in Ventura County are drawn by pumps from underground or are secured by diversion of water which a subsurface barrier or valley constriction has forced to the surface as the underground water drifts slowly oceanward along the stream valleys. The valleys and coastal plain consist of unconsolidated recent alluvium, the voids in which are filled to a level depending on circumstances, with water which has percolated into them from various sources.

The water table is at a considerable distance below the ground surface in parts of the valley fill, and the streams, flowing during the winter rains and for a period thereafter, lose all their water by percolation except in times of heavy discharge when the quantity is too large to percolate, at which times there is waste into the ocean. Other sources of supply to the underground water are that portion of the rainfall on the valley floor which percolates past the root zone of the various types of vegetation whether native or cultivated and similar deep percolation in the porous portions of the mountains and hills which flank the valleys. This water after having thus reached a zone from which it can not be dissipated by evaporation or plant transpiration, drifts to the valley and contributes to the underground supply, except the part which appears as springs on the mountain side and is evaporated or dissipated by the vegetation which grows at such points.

The water which reaches the subsurface reservoir of the valley is disposed of in a state of nature by evaporation and transpiration at the points where it rises to the surface or if the quantity is sufficient flows on the surface until diverted or until it again sinks. Irrigation of cultivated crops provides another way of disposal. The supply to the underground basins is widely erratic, varying during the year with the season, varying year by year with the wetness of the season and varying period by period as a wet cycle succeeds a dry. Disposal of the water of the underground basins although not uniform has a much smaller variation than the supply to them just as the fluctuations of a stream are smoothed in passing through a surface reservoir. The result is that the water table is in a constant state of slow fluctuation seasonally, annually and cyclically.

From the data gathered in this investigation and others of a similar nature, it is possible to approximately evaluate the percolation to the water table from any stream discharge entering each basin, the percolation to the water table from rainfall on the valley floor, the voids in the material of the valley fill (the reservoir capacity), the underground inflow and outflow through the valley fill, the amount used by native water-loving vegetation in areas of high water table,

the consumptive use by irrigated areas and the exportation. The method of study adopted was to treat each basin of each valley as a separate reservoir and estimate the supply to it over a term of years and the draft from it during that time, assuming that the area now irrigated had been irrigated during the period studied.

This method proved adequate for the basins of the Santa Clara Valley and for Oxnard Plain and consequently by comparison of rainfall during the five-year period of investigation with the long term rainfall together with interpretation of observed phenomena during the period a satisfactory conclusion as to shortage or surplus in these areas has been possible, and an evaluation can be made. In Ventura River Valley data are scarce and surplus or deficiency has not been evaluated.

In all the basins of Calleguas Creek the recent alluviums are shallow. A large number of the wells supplying irrigation water penetrate the Saugus formation which underlies the recent alluvium and forms large portions of the surrounding hills and mountains. This formation is porous and absorbs rain as does the basaltic range to the south of Calleguas Creek Basin. In some cases the wells penetrate the recent alluvium only but their yield is so large it is evident that the supplies available from rainfall on the valley floor and stream percolation could not maintain it. The only possible additional source would be inflow of water from the Saugus and other formations into which rainfall had penetrated in the mountains. The supply to these formations reaching any particular valley were not evaluated because there is no way with present knowledge, of estimating storage capacity in these formations, and the possible delay in rise of wells in the valley after a year of heavy rainfall because of the distance the water has to travel prevents accurate conclusions. Furthermore, a reliable estimate of the percolation of rainfall into them can not be made with present information. In addition, the rise or fall of the water table gives no basis for estimating change in storage. As a whole, therefore, the estimate of present situation as to water supply in these valleys contains many uncertainties and no effort has been made to evaluate the conclusions.

HYDROLOGICAL INVESTIGATION AND ANALYSIS

Precipitation

All known rainfall records were secured. Those from private observers were carefully compared day by day if daily records were available, or month by month if they were not. If an error was obvious for a short period, that period was estimated by comparison with authentic records, but if no reliable estimate could be made the record was thrown out. Additional stations were established where deemed advisable.

Not all records available are here published but Table 56 opposite page 200 shows the records at key stations used for the basis of this report. Plate II, page 18, shows the isohyetose lines of the entire area investigated and location of precipitation stations. Plate III, page 19, gives a cumulative mass curve of precipitation at Santa Paula showing the cyclic character typical of precipitation in southern California.

Stream Discharge

Data as to run-off are available at the following points and location is shown on frontispiece.

TABLE 6

LOCATION OF PERMANENT STREAM FLOW MEASURING STATIONS

Stream	Number	Location of gage	Period of record
Santa Clara River	1 W	Newhall Ranch Bridge	1927–28 to 1931–32
Santa Clara River	5 W	Mont. Ivo Bridge	1927–28 to 1931–32
Piru Creek	1 U	Near Piru	1911–12 to 1912–13
Piru Creek	2 W	Near Piru	1927–28 to 1931–32
Sespe Creek	4 U	Near Sespe	1911–12 to 1912–13
Sespe Creek	3 U	Bradfields Camp	1915–16 to 1925–26
Sespe Creek	2 W	Near Sespe	1927–28 to 1931–32
Hopper Creek	13 W	At Highway Bridge	1930–31 to 1931–32
Santa Paula Creek	5 U	Near Santa Paula	1911–12 to 1912–13
Santa Paula Creek	4 U	Near Santa Paula	1927–28 to 1931–32
Ventura River	6 U	Near Ojai	1911–12 to 1914–15 1921–22
Ventura River	7 U	At Casitas Bridge	1911–12 to 1913–14
Ventura River	12 W	At Casitas Bridge	1929–30 to 1931–32
Matilija Creek	6 W	Near Matilija Springs	1927–28 to 1931–32
North Fork	9 W	Near Wheeler Springs	1928–29 to 1931–32
Coyote Creek	8 W	Near Foster Park	1927–28 to 1931–32
San Antonio Creek	7 W	Near Ojai	1927–28 to 1931–32
Calleguas Creek	10 W	Near Camarillo	1928–29 to 1931–32

NOTE.—Those stations the number of which has the suffix "W" were established by the Division of Water Resources for this investigation. Those with suffix "U" were maintained by the U. S. G. S. or others. Daily records of all are found in U. S. G. S. Water Supply Papers.

The records at these stations were used to determine the rainfall-run-off relation, and the monthly run-off of all streams except Calleguas Creek was estimated for the 40-year period beginning with fall 1892 and ending with fall 1932. Pages 202 to 219 show the annual run-off, either estimated or measured, for each stream and also the waste into the ocean from Santa Clara and Ventura Rivers.

Stream Percolation

In addition to measurements at the established gaging stations stream measurements were made at all strategic points to determine percolation into the various basins.

These measurements give for their range a fairly definite relation between discharge at the upper end of the basin and percolation within the area. From similar relations determined elsewhere for similar and higher flows the probable relation for higher flows was approximated.* The relation between discharge in second-feet and percolation in second-feet as determined and as extended are shown on Plates V to X, as follows:

Santa Clara River—

Newhall Ranch Bridge to Torrey Road.
Torrey Road to Cavin Road.
Cavin Road to mouth of Sespe Creek.

Piru Creek—

Highway Bridge to Torrey Road.

* Bulletin No. 7, Division of Water Resources, "San Gabriel Investigation."

Hopper Creek—

Highway Bridge to Cavin Road.

Sespe Creek—

Canyon mouth to Highway Bridge.

These embrace all percolating areas in Santa Clara River Valley above Montalvo Basin. There is also percolation in Montalvo Basin but the extremely rapid fluctuations in discharge and variations in diversion of water entering the basin prevent establishing a satisfactory relation between discharge in second-feet and percolation. It was possible, however, to establish a fairly satisfactory monthly relation which is shown on the next series of plates.

From the curves of daily percolation, except as just noted, curves of monthly discharge in acre-feet were platted against monthly percolation as shown in Plates XI to XVI. These were used in subsequent computations of recharge of the underground basins by comparison to estimated monthly flows for the 40-year period at the upper limits of the basins. A curve was not drawn for Sespe Creek as there are daily records available for 16 years. Percolation in second-feet from Plate X was used for this and for the unmeasured years, the results are from comparison of similar measured years. The total capacity of this basin above lowest water table is only about 7000 acre-feet.

Monthly curves used are:

Santa Clara River—

Newhall Ranch Bridge to Torrey Road.
Torrey Road to Cavin Road.
Cavin Road to mouth of Sespe Creek.
Vicinity of Saticoy.

Piru Creek—

Highway Bridge to Torrey Road.

Hopper Creek—

Highway Bridge to Cavin Road.

4—8367—8375

PLATE V

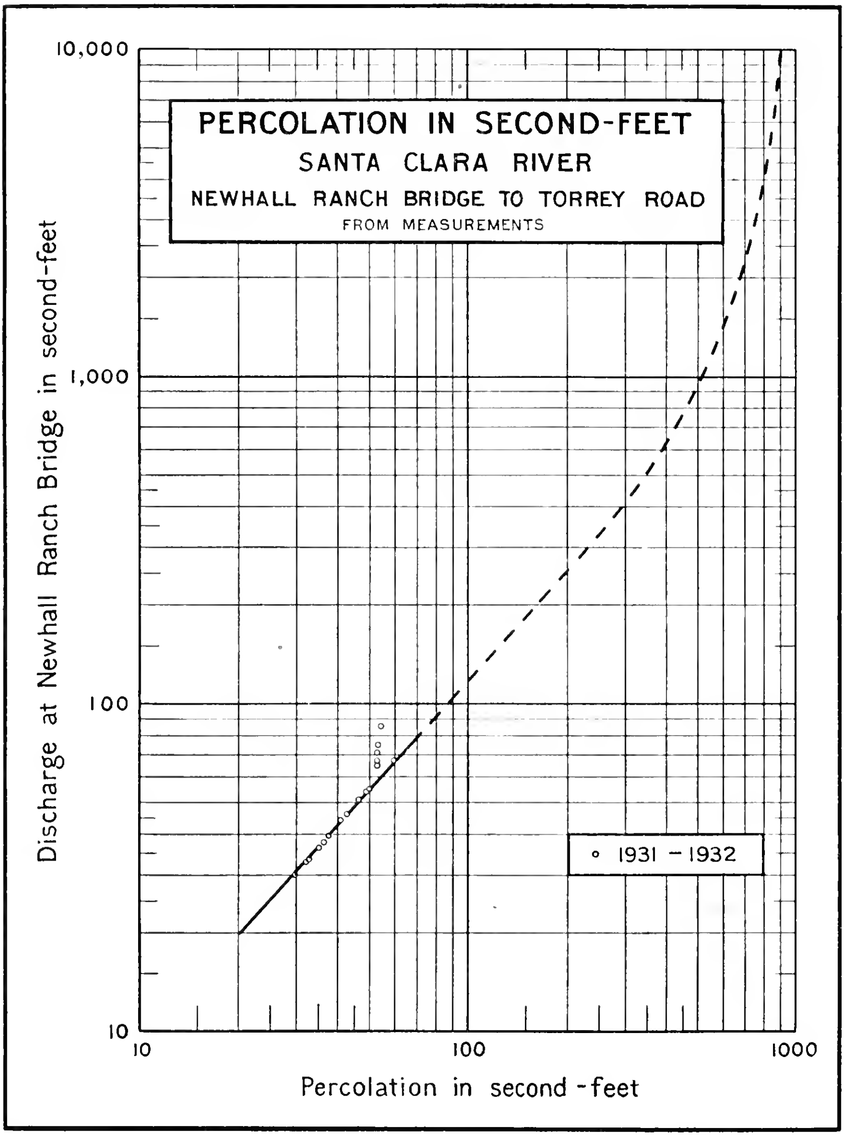

PERCOLATION IN SECOND-FEET
SANTA CLARA RIVER
NEWHALL RANCH BRIDGE TO TORREY ROAD
FROM MEASUREMENTS
o 1931 – 1932
Discharge at Newhall Ranch Bridge in second-feet
10,000
1,000
100
10
10
100
1000
Percolation in second-feet

PLATE VI

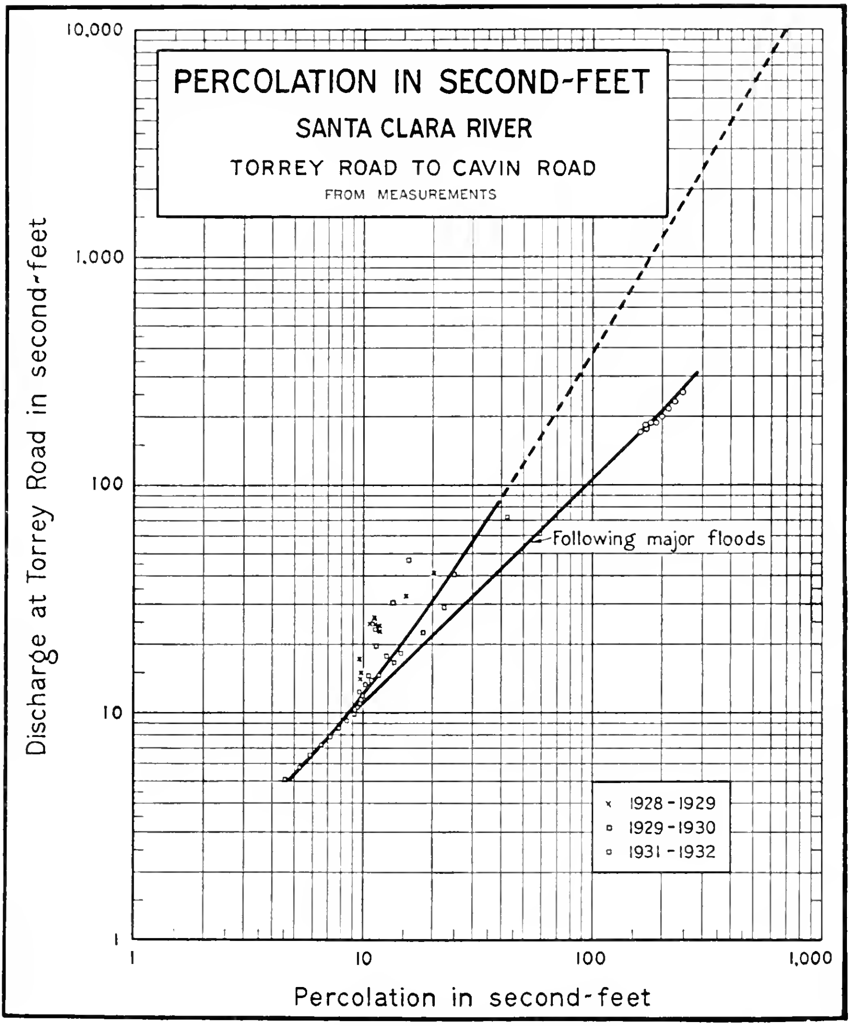

PERCOLATION IN SECOND-FEET
SANTA CLARA RIVER
TORREY ROAD TO CAVIN ROAD
FROM MEASUREMENTS
Discharge at Torrey Road in second-feet
Percolation in second-feet
10,000
1,000
100
10
1
1
10
100
1,000
Following major floods
1928-1929
1929-1930
1931-1932

PLATE VII

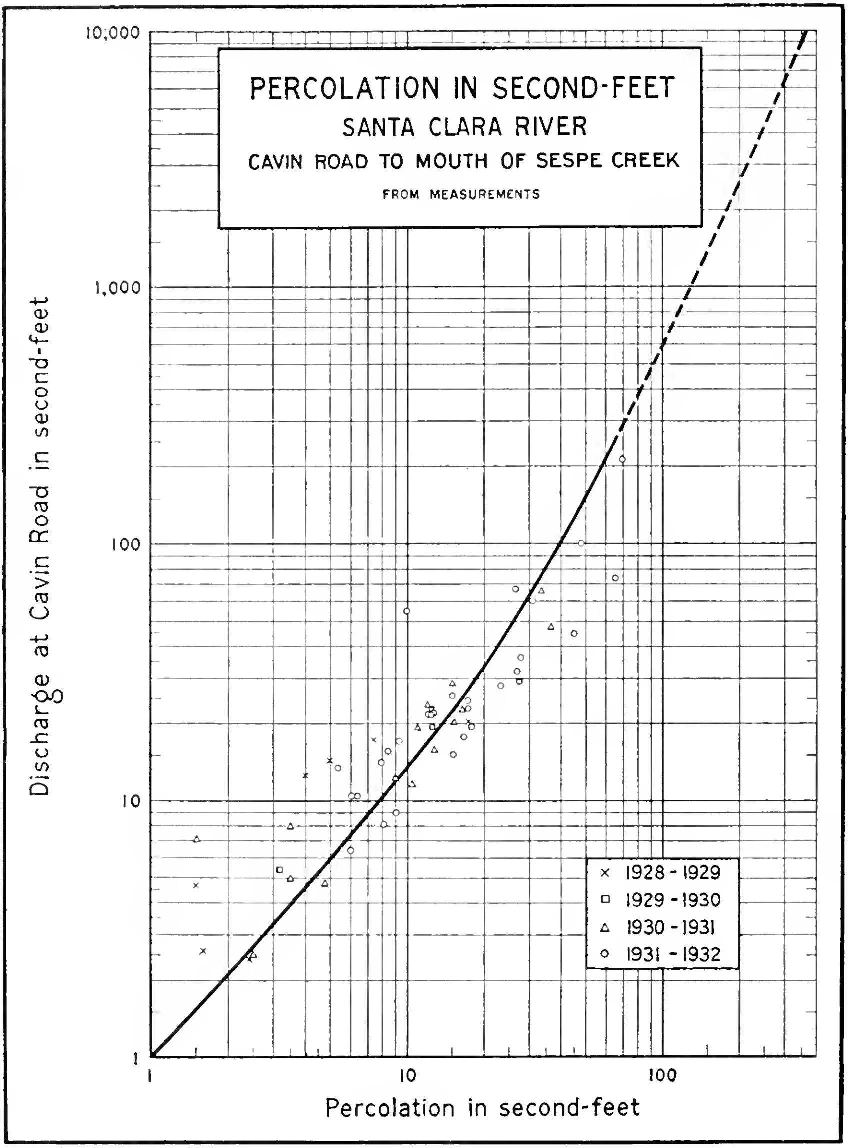

PERCOLATION IN SECOND-FEET
SANTA CLARA RIVER
CAVIN ROAD TO MOUTH OF SESPE CREEK
FROM MEASUREMENTS
10,000
1,000
100
10
1
1
10
100
Discharge at Cavin Road in second-feet
Percolation in second-feet
× 1928 - 1929
□ 1929 - 1930
△ 1930 - 1931
○ 1931 - 1932

PLATE VIII

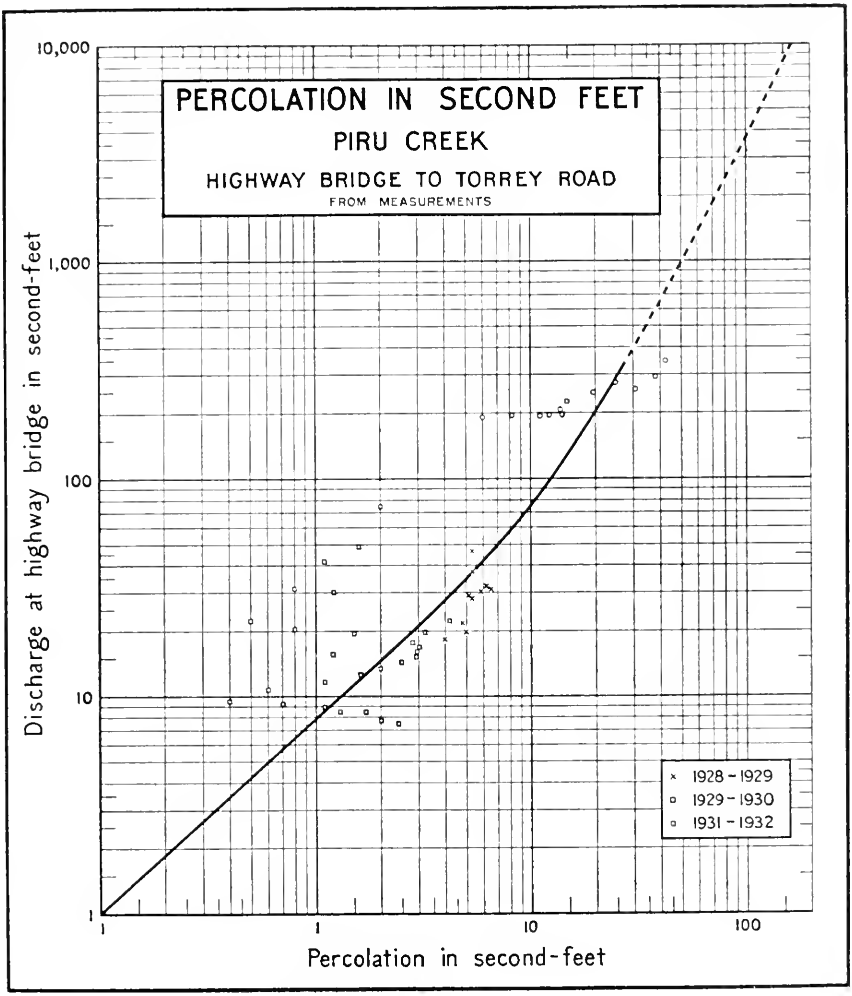

PERCOLATION IN SECOND FEET
PIRU CREEK
HIGHWAY BRIDGE TO TORREY ROAD
FROM MEASUREMENTS
10,000
1,000
100
10
1
1
10
100
Discharge at highway bridge in second-feet
Percolation in second-feet
× 1928 - 1929
▫ 1929 - 1930
○ 1931 - 1932

PLATE IX

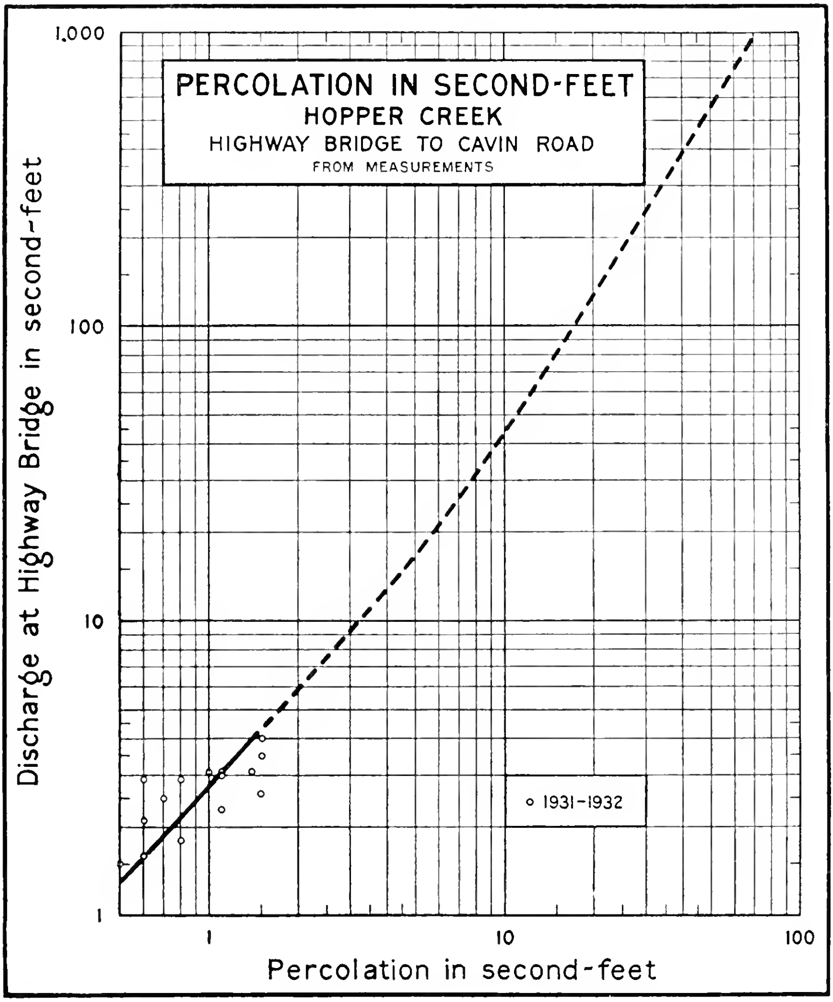

PERCOLATION IN SECOND-FEET
HOPPER CREEK
HIGHWAY BRIDGE TO CAVIN ROAD
FROM MEASUREMENTS
1,000
100
10
1
1
10
100
Discharge at Highway Bridge in second-feet
Percolation in second-feet
1931-1932

PLATE X

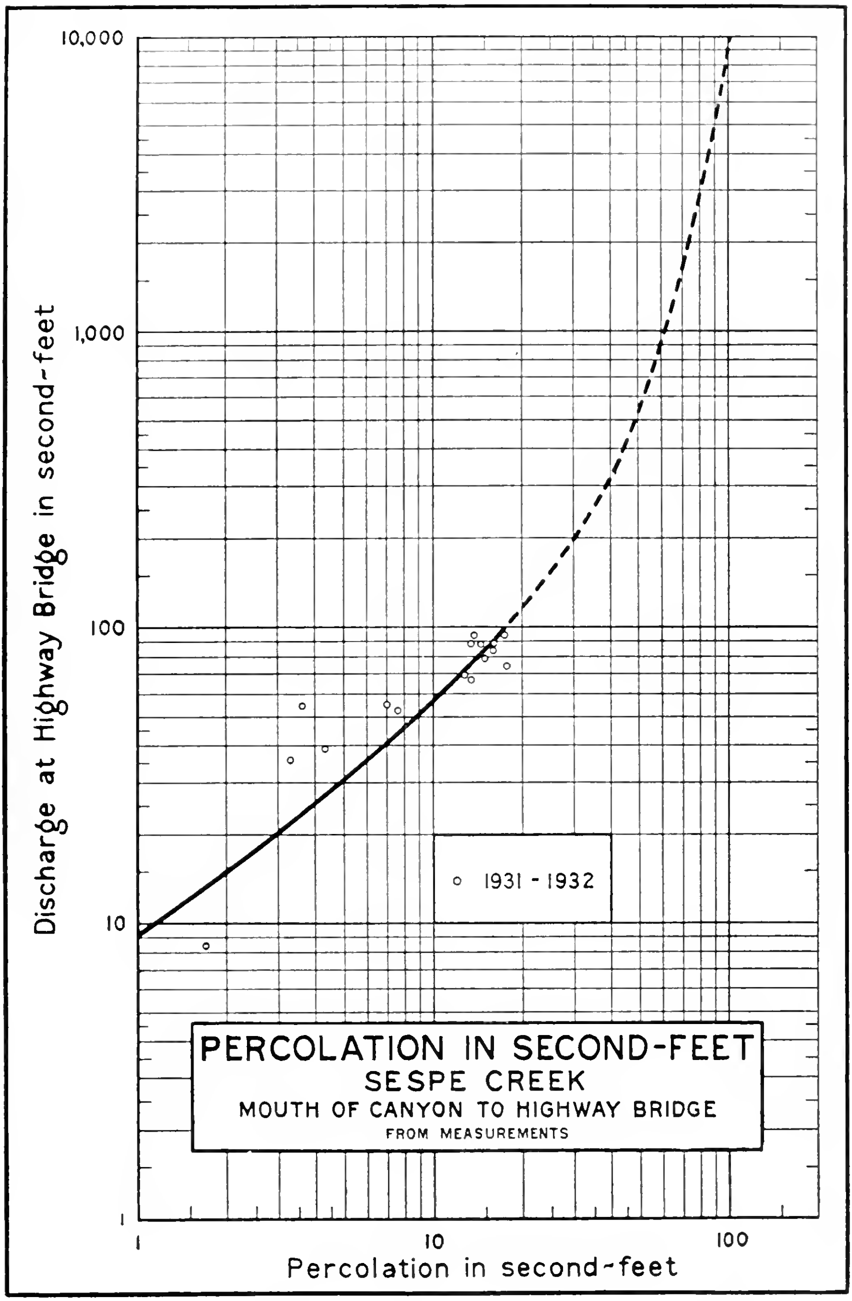

10,000
1,000
100
10
1
Discharge at Highway Bridge in second-feet
1
10
100
Percolation in second-feet
1931 - 1932
PERCOLATION IN SECOND-FEET
SESPE CREEK
MOUTH OF CANYON TO HIGHWAY BRIDGE
FROM MEASUREMENTS

PLATE XI

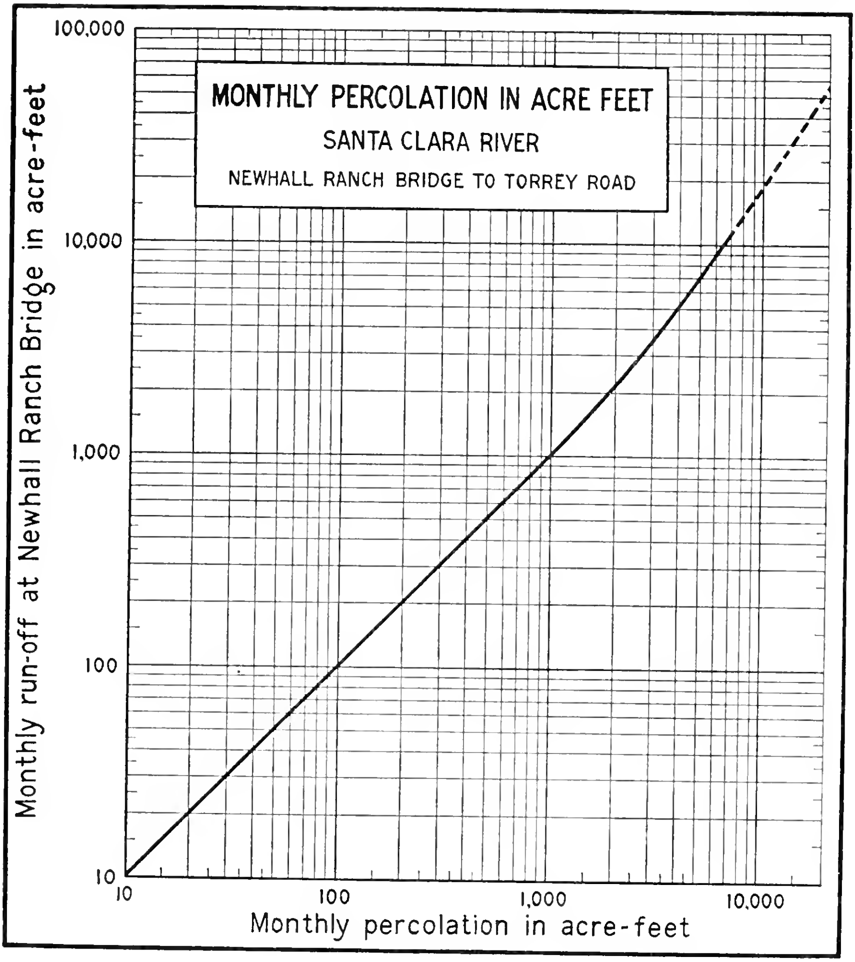

MONTHLY PERCOLATION IN ACRE FEET
SANTA CLARA RIVER
NEWHALL RANCH BRIDGE TO TORREY ROAD
Monthly run-off at Newhall Ranch Bridge in acre-feet
100,000
10,000
1,000
100
10
10
100
1,000
10,000
Monthly percolation in acre-feet

PLATE XII

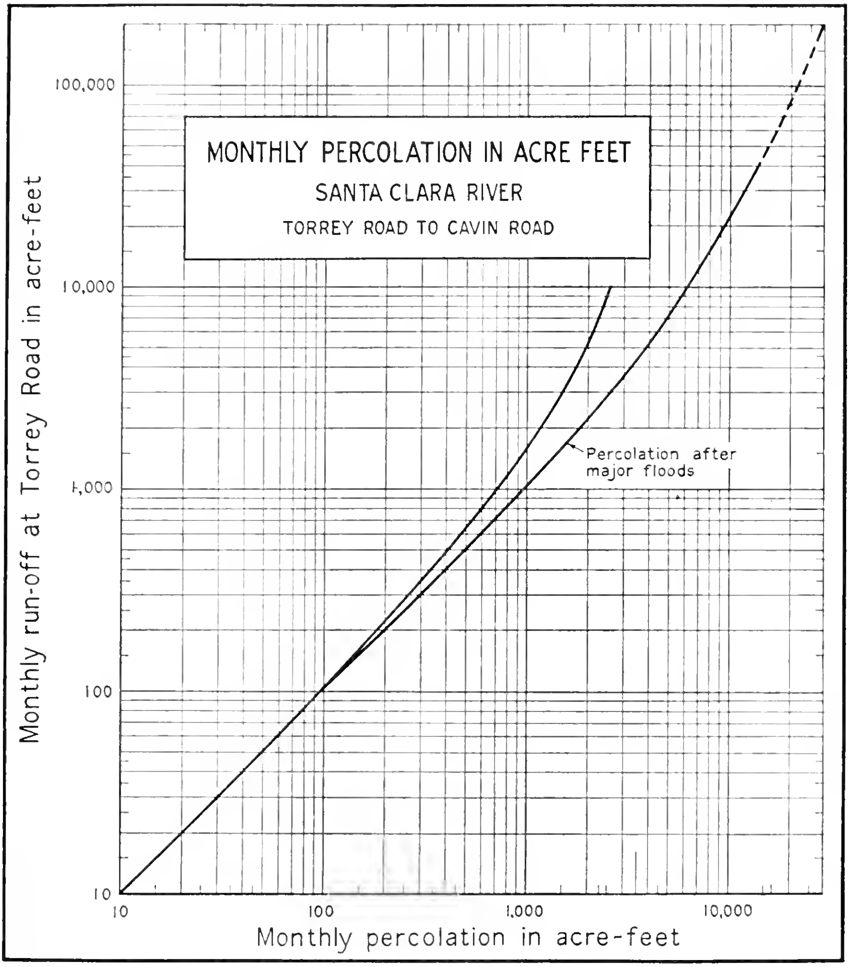

MONTHLY PERCOLATION IN ACRE FEET
SANTA CLARA RIVER
TORREY ROAD TO CAVIN ROAD
Percolation after major floods
Monthly run-off at Torrey Road in acre-feet
Monthly percolation in acre-feet
100,000
10,000
1,000
100
10
10
100
1,000
10,000

PLATE XIII

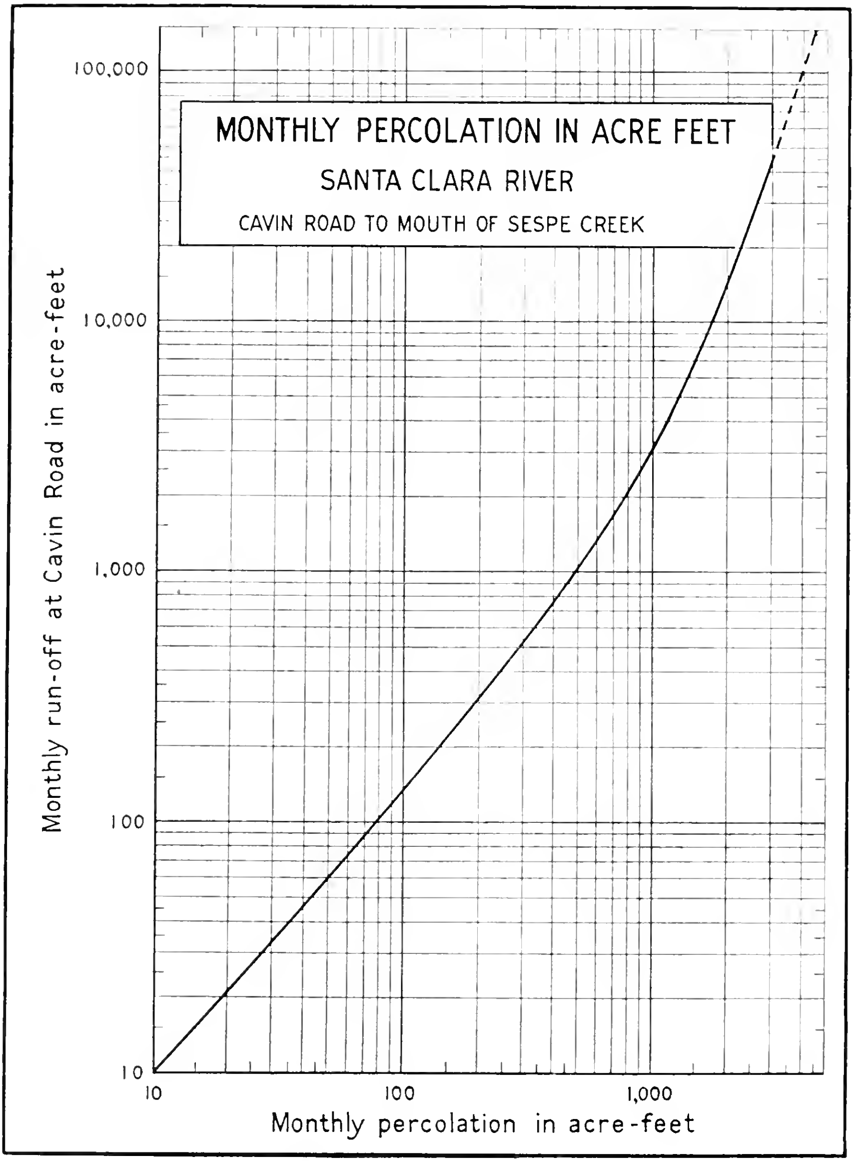

MONTHLY PERCOLATION IN ACRE FEET
SANTA CLARA RIVER
CAVIN ROAD TO MOUTH OF SESPE CREEK
100,000
10,000
1,000
100
10
10
100
1,000
Monthly run-off at Cavin Road in acre-feet
Monthly percolation in acre-feet

PLATE XIV

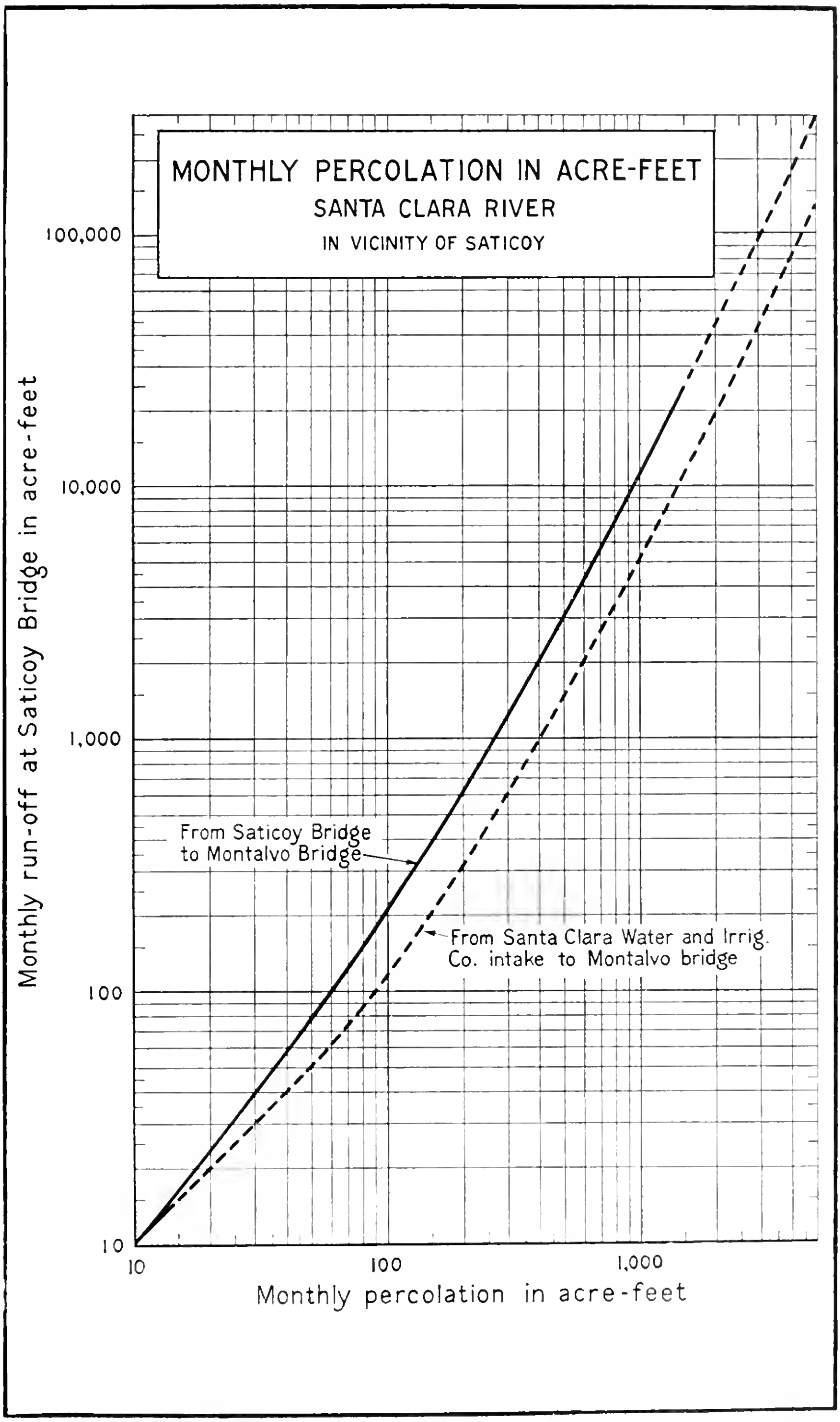

MONTHLY PERCOLATION IN ACRE-FEET
SANTA CLARA RIVER
IN VICINITY OF SATICOY
Monthly run-off at Saticoy Bridge in acre-feet
Monthly percolation in acre-feet
100,000
10,000
1,000
100
10
10
100
1,000
From Saticoy Bridge to Montalvo Bridge
From Santa Clara Water and Irrig. Co. intake to Montalvo bridge

PLATE XV

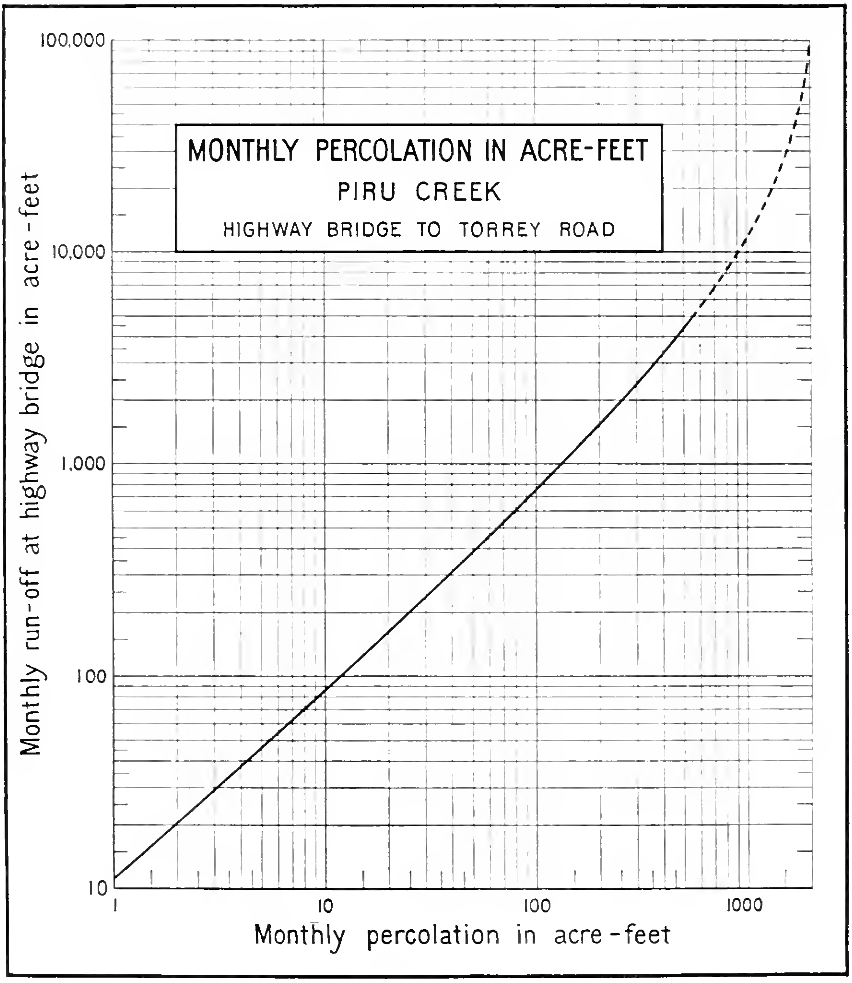
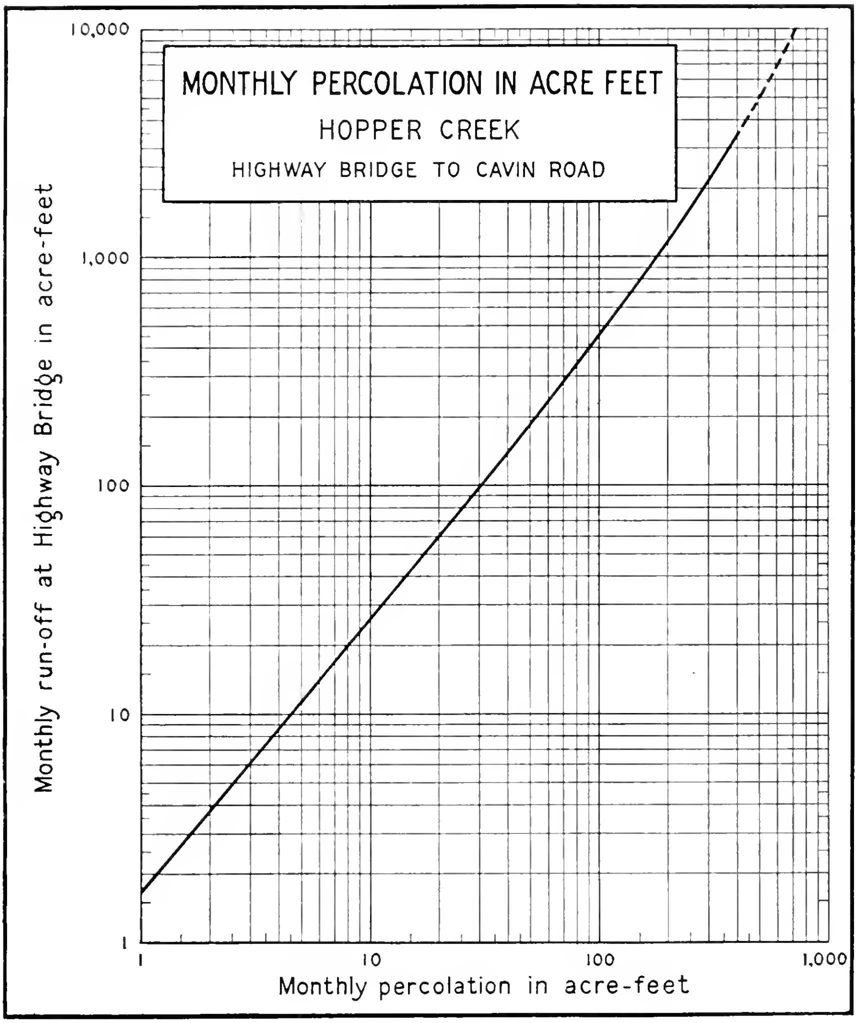

MONTHLY PERCOLATION IN ACRE-FEET
PIRU CREEK
HIGHWAY BRIDGE TO TORREY ROAD
Monthly run-off at highway bridge in acre-feet
100,000
10,000
1,000
100
10
1
10
100
1000
Monthly percolation in acre-feet

PLATE XVI


MONTHLY PERCOLATION IN ACRE FEET
HOPPER CREEK
HIGHWAY BRIDGE TO CAVIN ROAD
Monthly run-off at Highway Bridge in acre-feet
10,000
1,000
100
10
1
1
10
100
1,000
Monthly percolation in acre-feet

The season 1931–32 was the only year when discharge from the canyon mouth of Ventura River was sufficiently sustained to measure percolation. The losses are shown in Table 7.

TABLE 7

PERCOLATION IN UPPER VENTURA RIVER VALLEY, AVERAGE SECOND-FEET

Period	Discharge At Matilija Ranch Intake	Loss	Discharge At Meyer Road Crossing	Loss	Discharge At Oakview Road Crossing	Gain	Discharge At Ventura City Intake	Total loss, Matilija to Oakview
January 3 to 7, 1932—5 days	38.9	5.9	33.0	28 1	4.9	7.3	12.2	34.0
February 3 to 6, 1932—4 days	105.0	2.0	103.0	9.0	94.0	23.0	117.0	11.2
February 15 to 29, 1932—15 days	123.0	3.0	120.0	4.0	116.0	42.0	158.0	7.8
March 1 to 31, 1932—31 days	45.9	2.9	43.0	3.8	39.2	20.7	59.7	6.7

Distance between points in miles	.95	4.2	2.9	
Total distance, Matilija Ranch to Oakview Road				5.15

NOTE.—Percolation also occurs immediately below Oakview Crossing and above the rim of rising water. Measurements were not taken on this.

In addition to the locations shown, measurements were taken at Burnham Road between Meyer Road and Oakview which indicated a gain between Meyer Road and Burnham Road for a portion of the period, although the net loss from Meyer Road to Oakview still was consistent with prior and subsequent measurements. For this reason discharges at Burnham Road are not given as it is believed these measurements do not show true conditions.

Deep Percolation from Rainfall on Valley Floor

The method of estimating this is given in Chapter VI. By the method thus developed, the percolation for each storm during the period of investigation was calculated for each basin. The information thus developed was used to construct generalized curves by which the percolation by months during the 40-year period was estimated from rainfall records. This is not a large source of supply to the underground basin of Santa Clara Valley, being estimated at 20 per cent of the total. For Calleguas Creek the supply is smaller, as the rainfall is less, but is believed to be larger than the contribution from streams.

Underground Contribution from Porous Hills and Mountains

This is a small amount in Santa Clara Valley or the basin of Ventura River, but is probably the major source of supply in the basins of Calleguas Creek. As it is a small item in the total supply in Santa Clara Valley it was neglected. No attempt to calculate it was made for Calleguas Creek Basin.

Storage Capacity in Valley Fill

This is estimated as described in Chapter V.

Underground Flow

This refers to the underground flow from an upper into the next lower basin. No wholly satisfactory method of arriving at this is known. For this analysis, it was accepted that any quantity remaining after all contributions to and drafts on a basin had been evaluated was inflow underground if the residual quantity was plus and outflow if it was minus. This throws all error into the quantity. The quantities thus determined for each year were used to plat a curve of outflow as compared to water table elevation, as obviously the outflow must increase as the water table rises unless there are unusual conditions not found in any basins studied.

Consumption by Water-loving Plants

Where the water table is close to the surface will be found a growth of willows, etc. These cover 3670 acres in Santa Clara Valley and about 150 acres in Ventura River Basin above Casitas Road but the area is negligible in Calleguas Creek Basin. From other work it is estimated the willows of Santa Clara Valley consume 34 inches of water in depth per acre in the seven months from November to March, inclusive, and a total of 40 inches in depth per year per acre, causing a total loss from groundwater of 11,700 acre-feet per year and 500 acre-feet from rainfall which would have penetrated to the water table if they had not been present. This loss was proportioned in accordance with area covered by such vegetation as measured during the investigation. In Ventura River Basin the type of water-loving vegetation consumes 4.0 feet in depth annually, from determinations elsewhere.*

Irrigation Exportations

This refers to the exportation from one basin for use in another. Records were secured during the investigation.

Use by Irrigated Lands

In the Oxnard Plain where there is an impenetrable clay cap between the ground surface and the pumping strata and in Pleasant Valley where wells draw from the Saugus formation, percolation from irrigated land can not return to the source and consequently the use is the total water pumped. The surplus is drained into the ocean artificially. In Santa Clara Valley, Ojai Basin, Ventura Basin and the basins of Calleguas Creek other than Pleasant Valley, this surplus percolates again to the water table and is reused. In such cases the total use by each irrigated area is the water actually consumed by the plants and incidental evaporation and not the amount pumped. This consumptive use is smaller than the water applied. The values used for this analysis are as shown by the following table.

* Bulletin 44, "Water Losses Under Natural Conditions from Wet Areas in Southern California," South Coastal Basin Investigation, Division of Water Resources.

TABLE 8

ASSUMED CONSUMPTIVE USE OF WATER FOR IRRIGATION

Acre-feet per acre

Piru Basin	1.45
Fillmore Basin	1.33
Santa Paula Basin	1.15
Oxnard Plain	*0.90
Las Posas Valley	1.24
Simi Valley	1.21
Santa Rosa Valley	1.30
Pleasant Valley	*1.10
Ojai Basin	Not estimated
Ventura River Basin	Not estimated

* Total use.

CHAPTER V

BASIN CAPACITIES—METHOD OF COMPUTING SPECIFIC YIELD

The terms "ground water storage" and "storage capacity" as here used refer to the volume of the open voids or interstices available for the storage of water which can be entirely recovered. They do not include the volume occupied by water which can not be recovered due to the forces of adhesion and cohesion which give rise to the retention of water as films and in capillary openings.

Quoting Meinzer:* "The specific yield of a rock or soil is the percentage of its total volume that is occupied by gravity ground water, and the specific retention is the percentage of its total volume that is occupied by water which is not gravity ground water and which it will not yield to wells. Thus, the specific yield and the specific retention of a rock or soil are together equal to its porosity. If a rock has a specific yield of 8 per cent and a specific retention of 13 per cent its porosity is obviously 21 per cent. The specific yield of an impermeable rock is zero, its specific retention being equal to its porosity."

The terms "ground water storage" and "storage capacity" are the volumetric equivalents in acre-feet of the specific yield in per cent.

For computing storage capacity or change in storage the five minute lines of latitude and longitude are shown on U. S. Geological Survey maps of the region and were divided into 10 equal parts, resulting in a grid of areas one-half minute of latitude by one-half minute of longitude. Each covers an area of 174.7 to 175.8 acres** and an average of 175 acres was used in computations.

Groups of well logs were averaged and specific yield values computed for intervals of 50 feet in depth below the ground surface.

POROSITY, SPECIFIC RETENTION AND SPECIFIC YIELD

Sand and Gravel Samples from Santa Clara River Valley

Methods followed were those developed in South Coastal Basin Investigation of the Division of Water Resources.***

Sixteen samples were taken of sand and gravel in the Santa Clara River Valley to determine the porosity, specific retention and specific yield.

At the location for digging the sample, the ground surface was cleared of soil and leveled. A hole was dug, as small in area as possible at the top and widening with depth. All of the excavated mate-

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* Meinzer, O. E., The Occurrences of Ground Water in the United States, U. S. Geological Survey Bulletin 489, p. 51, 1923.

** Ganett, S. S., Geographic Tables and Formulas, U. S. Geological Survey Bulletin 650, p. 120, 1916.

*** Bulletin No. 45, Division of Water Resources, South Coastal Basin Investigation, "Geology and Ground Water Storage Capacity of Valley Fill."

rial was placed in sacks to be analyzed at the laboratory in Claremont maintained cooperatively by the Division of Water Resources by arrangement with Pomona College. The volume of the sediments excavated was determined by filling the holes with a measured volume of sand of uniform grain size. The sand was poured from a receptacle into the measuring can or graduate without packing and poured into the hole in the same manner and from the same height, in order that the sand when in the hole would occupy the same volume as it did in the measuring device.

At the laboratory, the samples were screened to segregate the constituent grains into the following grade sizes: Over 512 millimeters; 256 to 512 mm.; 128 to 256 mm.; 64 to 128 mm.; 32 to 64 mm.; 16 to 32 mm.; 8 to 16 mm.; less than 8 millimeters. The volume of the grade sizes over 8 millimeters was determined by submerging the particles in water and measuring the volume of the water displaced. The particles under 8 millimeters in diameter were separated by screens shaken mechanically into the following grade sizes: 4 to 8 mm.; 2 to 4 mm.; 1 to 2 mm.; $\frac{1}{2}$ to 1 mm.; $\frac{1}{4}$ to $\frac{1}{2}$ mm.; and less than $\frac{1}{8}$ mm. The volume of the various grade sizes under 8 millimeters in diameter was determined by dividing the dry weight by the specific gravity. Specific gravity determinations were not made on the samples, but a value of 2.68 was used, as this is the average specific gravity of a number of samples from stream cones in the South Coastal Basin as determined in the Claremont laboratory. The total volume of the solid aggregate subtracted from the measured volume of the hole gave the volume of pore space in the gravel as it existed in the field.

The specific retention of the sample was estimated from its mechanical analysis.* The porosity in per cent minus the specific retention in per cent gave the specific yield in per cent.

Location of Samples

The locations of the samples are given below. The sample numbers in parentheses are the sample numbers in Bulletin No. 45.

Sample No. 2, (G–125). Gravel sample from Kellerman pit, about 200 feet east of Torrey Road and 50 feet south of Howe Road. Depth of sample 103 feet to 105 feet, underlain by a clay streak and overlain by several feet of clean gravel.

Sample No. 4, (G–127). Gravel sample from 100 feet west of Highway No. 99 at north end of Pico Creek Bridge, from a bench about three feet above the present stream bed.

Sample No. 5, (G–128). Gravel sample from 150 feet north of sample No. 4, in the same gravel deposit.

Sample No. 6, (G–129). Gravel sample from 150 feet east of Bouquet Canyon Road and 200 feet south of the south end of the Santa Clara River Bridge, from bench about 10 feet above the present river bed. The gravel was loose and caved readily. A large sample was taken because of the large size of the top opening (approximately 8 by 14 inches) and because of sporadic boulders up to seven inches.

* Bulletin No. 45, *supra*.

Sample No. 7, (G–130). Gravel sample from west side of gravel pit, approximately 100 feet southwest of the Los Angeles aqueduct and 1200 feet northwest of Mint Canyon Road.

Sample No. 8, (G–131). Gravel sample from gravel pit east of Piru Creek and south of the highway.

Sample No. 9, (G–132). Gravel sample from 500 feet south of the Santa Clara River crossing southwest of Lang, from bench about three feet above the present river bed.

Sample No. 10, (G–133). Gravel sample from five feet north of sample No. 9.

Sample No. 12, (G–135). Sand sample from 2000 feet east of the south end of Saticoy Bridge over the Santa Clara River.

Sample No. 13, (G–136). Sand sample three feet from sample No. 12.

Sample No. 14, (G–137). Sand sample from 1500 feet west of the middle of Fillmore Bridge over the Santa Clara River.

Sample No. 15, (G–138). Sand sample 10 feet from sample No. 14.

Sample No. 16, (G–139). Gravel sample 10 feet from sample No. 15.

Sample No. 17, (G–140). Gravel sample five feet from sample No. 16.

Sample No. 18, (G–141). Coarse sand and fine gravel from 300 feet north of the south bank of the Santa Clara River and 50 feet west of Torrey Road.

Sample No. 19, (G–142). Sand sample from 25 feet north of sample No. 18.

Mechanical Analyses

Of these samples, numbers 12, 13, 14 and 15 were sand samples. Number 13 was a tight, well indurated, rather dirty sand. Its porosity was 36.5 per cent and its specific yield 24.8 per cent. The average for the other three clean river sands was 41.8 per cent porosity and 31.4 per cent specific yield.

Samples numbers 18 and 19 were of coarse sand and fine gravel. Their average porosity was 37.6 per cent and their average specific yield 31.7 per cent.

The other ten samples were of gravel. Of these, numbers 2, 8, 16 and 17 were of clean, unaltered gravels. The others were more dirty and had a reddish color due to oxidation. For the four clean samples the average porosity was 18.9 per cent and the average specific yield 15.0 per cent. For the six partially altered samples the average porosity was 23.4 per cent and the average specific yield 18.0 per cent. This does not mean that dirty, altered gravels have a higher specific yield than clean gravels, but that representative averages can not be obtained from so few samples over so large an area.

PLATE XVII

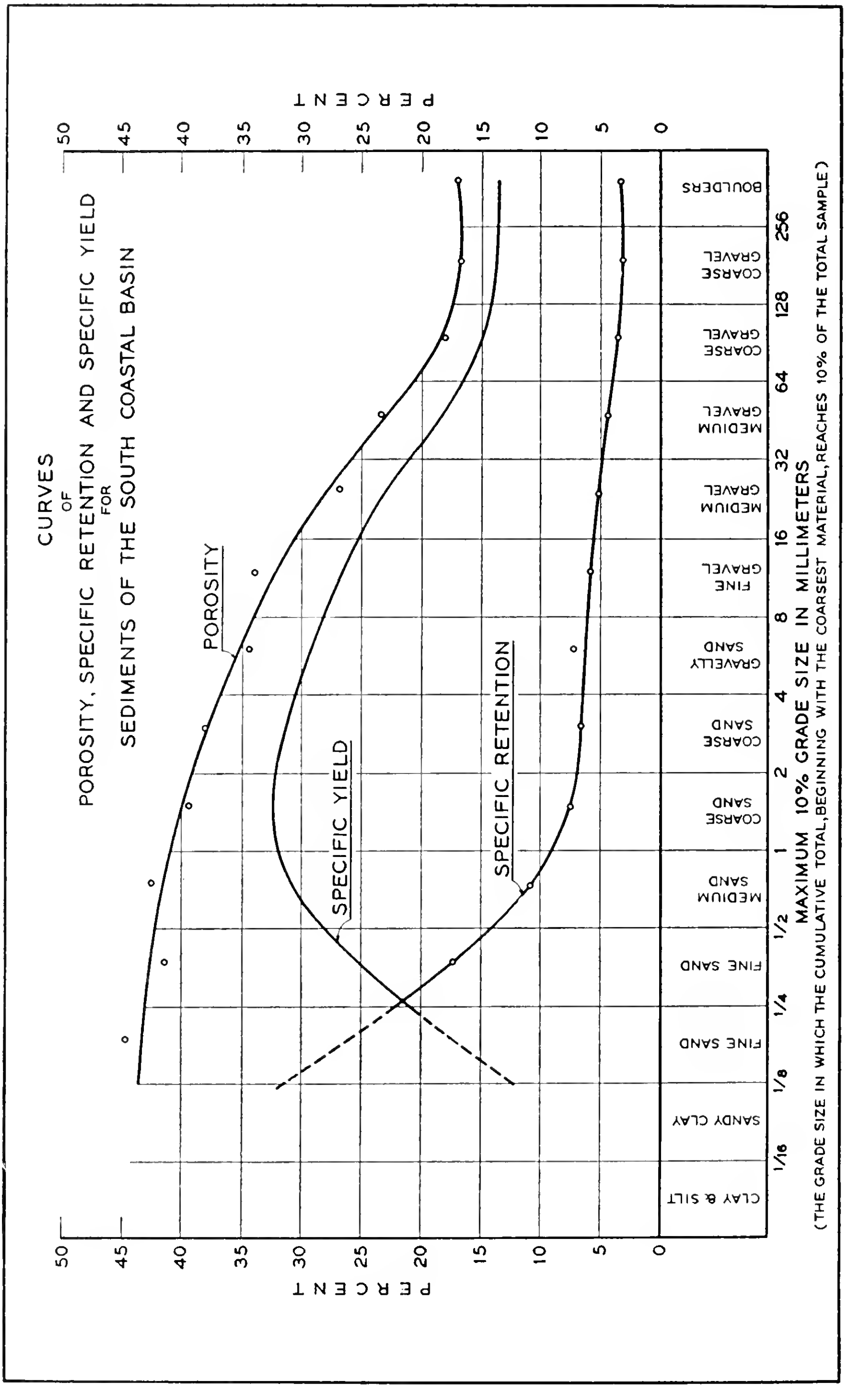

CURVES
OF
POROSITY, SPECIFIC RETENTION AND SPECIFIC YIELD
FOR
SEDIMENTS OF THE SOUTH COASTAL BASIN
POROSITY
SPECIFIC YIELD
SPECIFIC RETENTION
PERCENT
0 5 10 15 20 25 30 35 40 45 50
CLAY & SILT
SANDY CLAY
FINE SAND
FINE SAND
MEDIUM SAND
COARSE SAND
COARSE SAND
GRAVELLY SAND
FINE GRAVEL
MEDIUM GRAVEL
MEDIUM GRAVEL
COARSE GRAVEL
COARSE GRAVEL
BOULDERS
1/16 1/8 1/4 1/2 1 2 4 8 16 32 64 128 256
MAXIMUM 10% GRADE SIZE IN MILLIMETERS
(THE GRADE SIZE IN WHICH THE CUMULATIVE TOTAL, BEGINNING WITH THE COARSEST MATERIAL, REACHES 10% OF THE TOTAL SAMPLE)

TABLE 9

POROSITY AND SPECIFIC YIELD OF SAMPLES

	Sample number															
	2	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19
Porosity in per cent	21.2	23.7	25.0	26.5	21.2	18.5	23.2	20.7	43.7	36.5	42.2	39.5	15.6	20.1	37.7	37.4
Retention in per cent	5.0	6.1	6.0	4.6	5.6	3.0	4.8	5.0	11.5	11.7	10.5	9.3	3.9	3.6	5.3	6.4
Yield in per cent	16.2	17.6	19.0	21.9	15.6	15.5	18.4	15.7	32.2	24.8	31.7	30.2	11.7	16.5	32.4	31.0

Specific Yield of Sands

An inspection of Table 9 shows that gravel samples have widely varying porosities and specific yields. The same is true for sand samples. It is obvious that a representative value for specific yield of gravel or of sand can not be obtained by determining the specific yield of one or two samples from that area. The representative value should be obtained by averaging a large number of samples. In the Santa Clara River Valley there are not many localities where good gravel samples can be obtained as the surface deposits along the river are chiefly sand or silt with some streaks of gravel exposed which are not of great enough vertical thickness to sample. Gravel pits at Piru, Fillmore and Saticoy afford good gravel exposures. In the South Coastal Basin several hundred gravel samples were dug for porosity determination. The rock types there are similar to the rock types in the alluvium of the Santa Clara River. Plate XVII shows curves of porosity, specific retention and specific yield for 201 samples of continental deposits from the South Coastal Basin. The samples were grouped, averaged and plotted according to their maximum 10 per cent grade size. By the term "maximum 10 per cent grade size"* is meant that grade size of a sample in which the cumulative total of the coarsest material reaches 10 per cent of the total sample. It is a grade size which is more sensitive to the degree of sorting than either the absolute maximum size or the mean size.

For the 16 samples from the Santa Clara River Valley the average porosity, specific retention and specific yield for each maximum 10 per cent grade size was as follows:

TABLE 10

POROSITY, SPECIFIC RETENTION AND SPECIFIC YIELD OF SAMPLES FROM SANTA CLARA RIVER VALLEY

Maximum 10 per cent grade size, millimeters	Number of samples	Average porosity, per cent	Average specific retention, per cent	Average specific yield
½ to 1	4	40.5	10.8	29.7
1 to 2	2	37.5	5.8	31.7
16 to 32	3	23.3	5.7	17.6
32 to 64	5	22.3	4.7	17.6
64 to 128	2	17.1	3.5	13.6

The above specific yield values for the various grade sizes for the Santa Clara River Valley samples are slightly lower than the

* Bulletin No. 45, *supra.*

specific yield values for corresponding grade sizes from the South Coastal Basin. Because of the far greater number of samples from the South Coastal Basin, it is believed that they give a more representative average than the few samples from the Santa Clara River Valley and that by comparison the values for Santa Clara can be established.

For any given grade size the specific yield can be fairly accurately determined. In actual practice, the greatest difficulty lies in interpreting the drillers' logs, which are the basis for estimates of specific yield, and determining what grade sizes are meant by his terms gravel, sand, silt, muck, rock, etc. What one driller calls a coarse sand another may call a fine gravel. What one driller terms a sand in an area where good gravels are abundant he may term a gravel in areas where good gravels are scarce.

It may be assumed that the term "sand" as commonly used by well drillers includes particles whose dominant grade size varies from a minimum of one-fourth millimeter to a maximum of four millimeters in diameter. As the dominant grade size for sand is commonly one grade size smaller than the maximum 10 per cent grade size, the corresponding maximum 10 per cent grade size limits for the drillers' term "sand" would be one-half to eight millimeters. From the specific yield curve it is seen that the average specific yield of samples having the maximum 10 per cent grade size within the limits of one-half to eight millimeters is as follows:

Maximum 10 per cent grade size	*Specific yield*
½ to 1 millimeter	30.9 per cent
1 to 2 millimeters	32.4 per cent
2 to 4 millimeters	31.3 per cent
4 to 8 millimeters	29.1 per cent
Average	30.9 per cent

The average specific yield is 30.9 per cent. This is approximately the highest point on the specific yield curve on Plate XVII. Hence, if the driller included either coarser or finer material under his term "sand" the specific yield would be lowered. Dirty or clayey sand would also lower the specific yield. Experience in inspecting samples from drilling wells has shown that it is quite common for drillers to log fine sand as "sand." But fine sand, i.e., particles of dominant grade size of one-sixteenth to one-fourth millimeter,* has an average specific yield as shown by the specific yield curve of only 21.1 per cent. For the computations for this report a value of 27 per cent was used as the specific yield for sand. The specific yield value used for fine sand was 18 per cent. Mixtures of sand and clay occur and naturally their yield is variable. In this report a specific yield value of 9 per cent was used for sandy clay.

Specific Yield of Gravels

Along the river area of Santa Clara River Valley the surface deposits are of sand and silts with some gravels including cobbles up to ten inches (254mm.) in diameter. The gravel pit at Saticoy exposes very few boulders over 10 inches in diameter. The maximum 10 per

* Wentworth, C. K., A scale of grade and class terms for clastic sediments, Jour. Geology, V. 30, No. 5, pp. 377–392, 1922.

cent grade size for gravels is usually one grade size smaller than the absolute maximum size. Hence, the largest common maximum 10 per cent size for the Santa Clara River area is 64 to 128 millimeters. The specific yield for each maximum 10 per cent grade size from 8 to 128 millimeters from Plate XVII is as follows:

Maximum 10 per cent grade size	*Specific yield*
8 to 16 millimeters	26.6 per cent
16 to 32 millimeters	22.8 per cent
32 to 64 millimeters	18.4 per cent
64 to 128 millimeters	15.4 per cent

The average for these four grade sizes is 20.6 per cent specific yield. A value of 21 per cent was used as the specific yield for gravels in the river area of Santa Clara River Valley.

Boulders larger than 10 inches are common in the alluvial cones of Piru, Sespe and Santa Paula Creeks, and in the Timber Canyon Cone. The specific yield for each maximum 10 per cent grade size from 8 to 512 millimeters from Plate XVII is as follows:

Maximum 10 per cent grade size	*Specific yield*
8 to 16 millimeters	26.6 per cent
16 to 32 millimeters	22.8 per cent
32 to 64 millimeters	18.4 per cent
64 to 128 millimeters	15.4 per cent
128 to 256 millimeters	13.7 per cent
256 to 512 millimeters	13.7 per cent

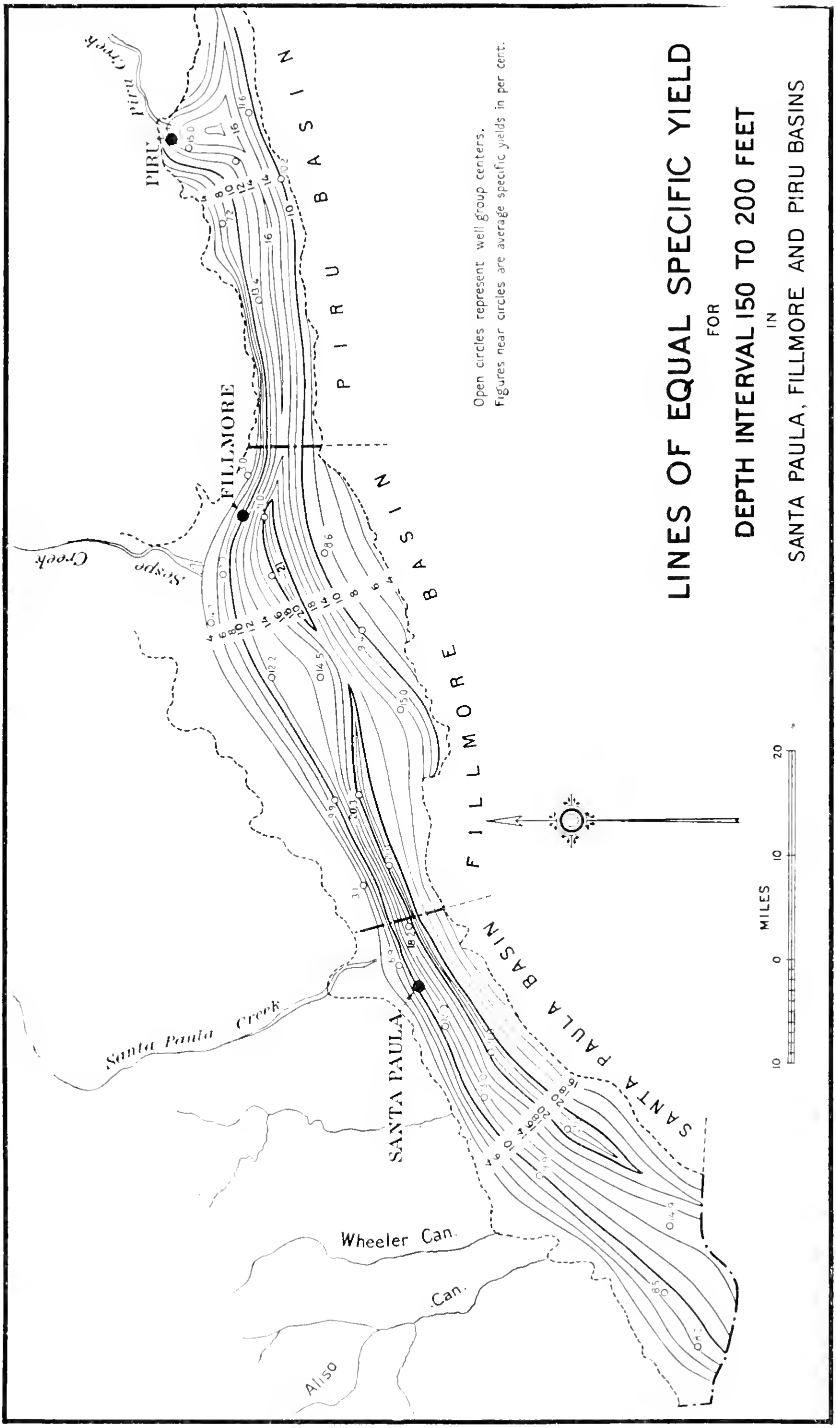
The average specific yield for these six maximum 10 per cent grade sizes is 16.8 per cent. But boulders are common in these cones up to 40 inches (1016mm.) in diameter and larger. No mechanical analyses were made on samples whose maximum 10 per cent grade size was greater than 512 millimeters (20 inches). However, there is no good reason to believe that the specific yield curve (Plate XVII) should rise as the maximum 10 per cent grade size becomes greater than 512 millimeters. Using 13.7 per cent as the specific yield for the 512 to 1024 millimeters and 1024 to 2048 millimeters maximum 10 per cent grade sizes, and averaging these with the other six grade sizes from 8 to 512 millimeters, gives an average specific yield of 16.3 per cent. As the larger maximum 10 per cent grade sizes are more common than the 8 to 16 grade size, a value of 15 per cent was used as the specific yield for gravel on the north side area of Santa Clara River Basin.

Gravels vary from good, clean gravel to cemented gravels or mixtures of gravel and clay. Their yields vary depending on the degree of cementing or the proportion of clay. Specific yields were assigned in the ratio of 3–2–1. That is, where the specific yield was 21 per cent for gravel, tight gravel was assigned a specific yield of 14 per cent and gravelly clay 7 per cent. For the north side areas of the Santa Clara River Valley where the specific yield of gravel was 15 per cent, tight gravel was assigned a specific yield of 10 per cent and gravelly clay 5 per cent.

Specific Yield of Clay

True clay can be considered as nonproductive, or, at best, as yielding slowly 1 or 2 per cent. Well drillers have a tendency to log sandy clays and sometimes silts as clays but sandy clays and silts should

PLATE XVIII


LINES OF EQUAL SPECIFIC YIELD
FOR
DEPTH INTERVAL 150 TO 200 FEET
IN
SANTA PAULA, FILLMORE AND PIRU BASINS
Open circles represent well group centers.
Figures near circles are average specific yields in per cent.
PIRU BASIN
FILLMORE BASIN
SANTA PAULA BASIN
PIRU
FILLMORE
SANTA PAULA
Piru Creek
Sespe Creek
Santa Paula Creek
Wheeler Can.
Can.
Aliso
MILES
10 0 10 20

yield some water. In this report, where a formation is definitely clay, a yield of 1 per cent has been used. Where the formation is clayey, but is not definitely or entirely clay, but appears to include sandy clay or silt, a yield of 3 per cent has been used.

Summary of Specific Yield Values Used for Santa Clara River Basins

A summary of the specific yield values used for the Piru, Fillmore and Santa Paula Basins follows:

Formation	*Specific yield* *River areas*	*North Side area*
Gravel	21 per cent	15 per cent
Tight gravel	14 per cent	10 per cent
Gravelly clay	7 per cent	5 per cent

Formation	*All areas*
Sand	27 per cent
Tight sand	18 per cent
Sandy clay	9 per cent
True clay	1 per cent
Doubtful clay	3 per cent

Specific Yield Contours

For the purpose of getting the average specific yields for the individual coordinate units, wells in the Piru, Fillmore and Santa Paula Basins were combined into natural groups. The formations were averaged by 50 foot intervals from the ground surface to depth 250 feet and the per cent specific yield determined for each interval. The formations were listed under eight headings: (1) True Clay; (2) Doubtful Clay; (3) Sandy Clay; (4) Gravelly Clay; (5) Sand; (6) Fine Sand; (7) Tight Gravel; (8) Gravel.

The centers of gravity of the well groups were marked on a map, and given the specific yield values determined by the well group averages. Then specific yield contours were drawn, so that all points on any contour have the same specific yield. This was done for each 50-foot depth interval. Plate XVIII shows specific yield contours for Piru, Fillmore and Santa Paula Basins for the depth interval 150 to 200 feet.

Oxnard Plain, Nonpressure Area

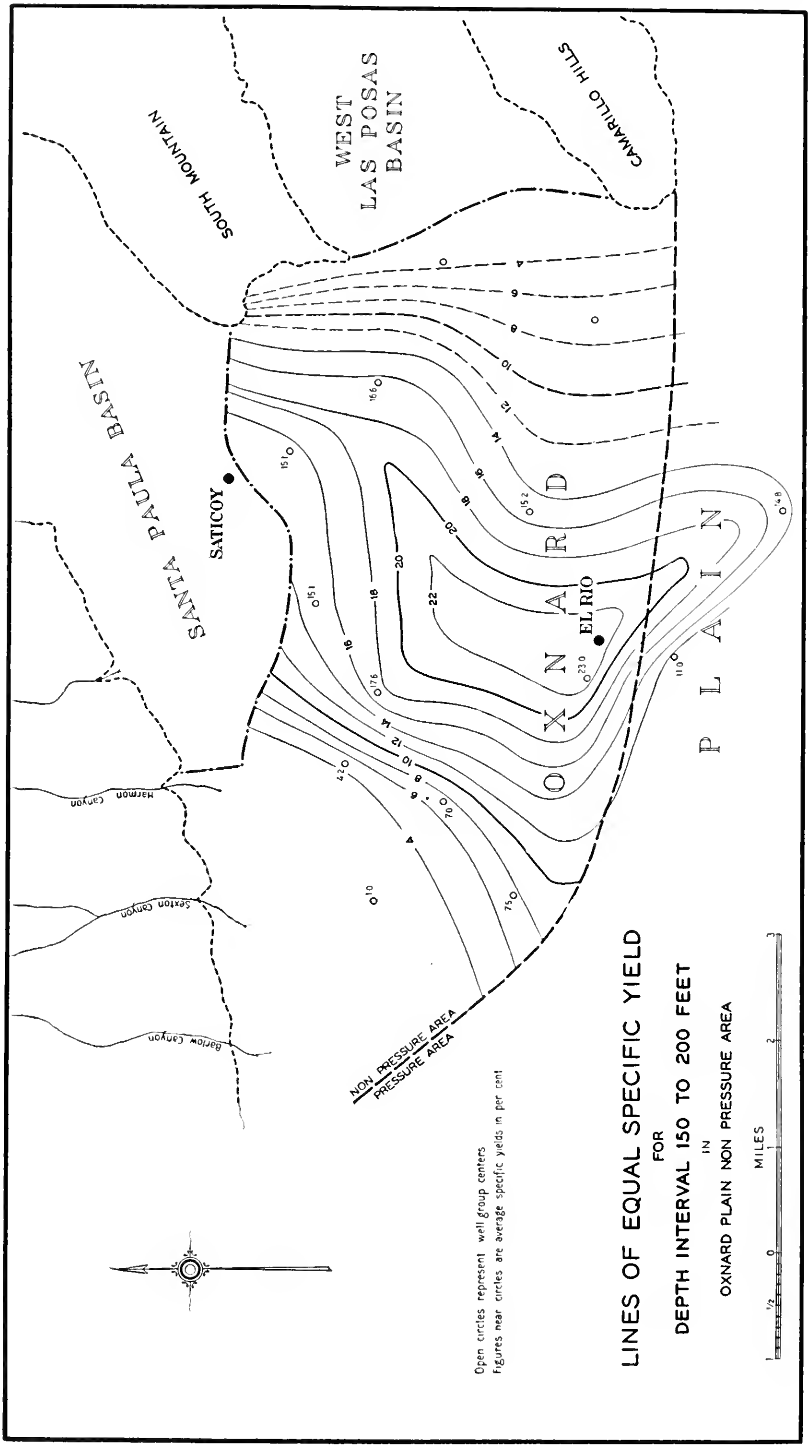
On the Oxnard Plain representative gravel samples were not available. The same procedure was followed as in Santa Clara River Valley and the same specific yield values were used. Boulders larger than those appearing in the Saticoy gravel pit should not occur in any abundance in the river cone deposits of sand and silt to the southwest. Averages on samples of marine sands in South Coastal Basin show that their specific yield is no higher than continental sands.

From the well group averages, specific yield contours were drawn for each 50-foot depth interval. One set of these contours is presented on Plate XIX to illustrate the general shape of the specific yield contours in the Oxnard Plain nonpressure area, where the condition of deposition of sediments changes from that of a confined valley to an alluvial plain.

Ojai Basin

In the Ojai Basin there are very few localities where good samples can be taken for determining the porosity and specific yield of the

PLATE XIX



LINES OF EQUAL SPECIFIC YIELD
FOR
DEPTH INTERVAL 150 TO 200 FEET
IN
OXNARD PLAIN NON PRESSURE AREA

gravels because the gradation is very rapid between the very large boulders at the northeastern end of the valley and the silts and clays at the southwestern end of the valley. Most of the gravels exposed contain boulders so large that representative samples can not be taken. Only two gravel samples were dug in Ojai Valley. They were taken from the bank of San Antonio Creek north of the Ojai Avenue Bridge. Their mechanical analyses are shown in Table 11. No specific gravity determinations were made on the particles under 8 millimeters in diameter. A specific gravity of 2.68 was assumed as this is the approximate specific gravity of particles derived from areas of crystalline rocks. As the alluvium of Ojai Valley is derived from sedimentary formations, the specific gravity assumed may be slightly high and the resulting porosity and specific yield slightly high.

TABLE 11

POROSITY AND SPECIFIC YIELD OF GRAVEL SAMPLES FROM OJAI VALLEY

	Sample No. 11	Sample No. 20
Porosity in per cent	21.9	24.1
Retention in per cent	2.1	2.1
Yield in per cent	19.8	22.0

Although computations of capacity were made for this basin they were not used as it appears difficult to correctly evaluate the voids.

Upper Ventura River Valley

In Upper Ventura River Valley the extremely large size of the boulders make it impractical to dig field samples to determine porosity. Boulders occur as large as 7 feet in diameter. So far as is known, no determination of porosity, specific retention or specific yield have been made anywhere on samples containing boulders over 512 millimeters (20 inches) in diameter. For the Upper Ventura River Valley it is estimated that the average specific yield of the alluvium composing the basin is not over 10 per cent but storage capacity computations were not used.

BASIN CAPACITIES AND STORAGE CHANGES

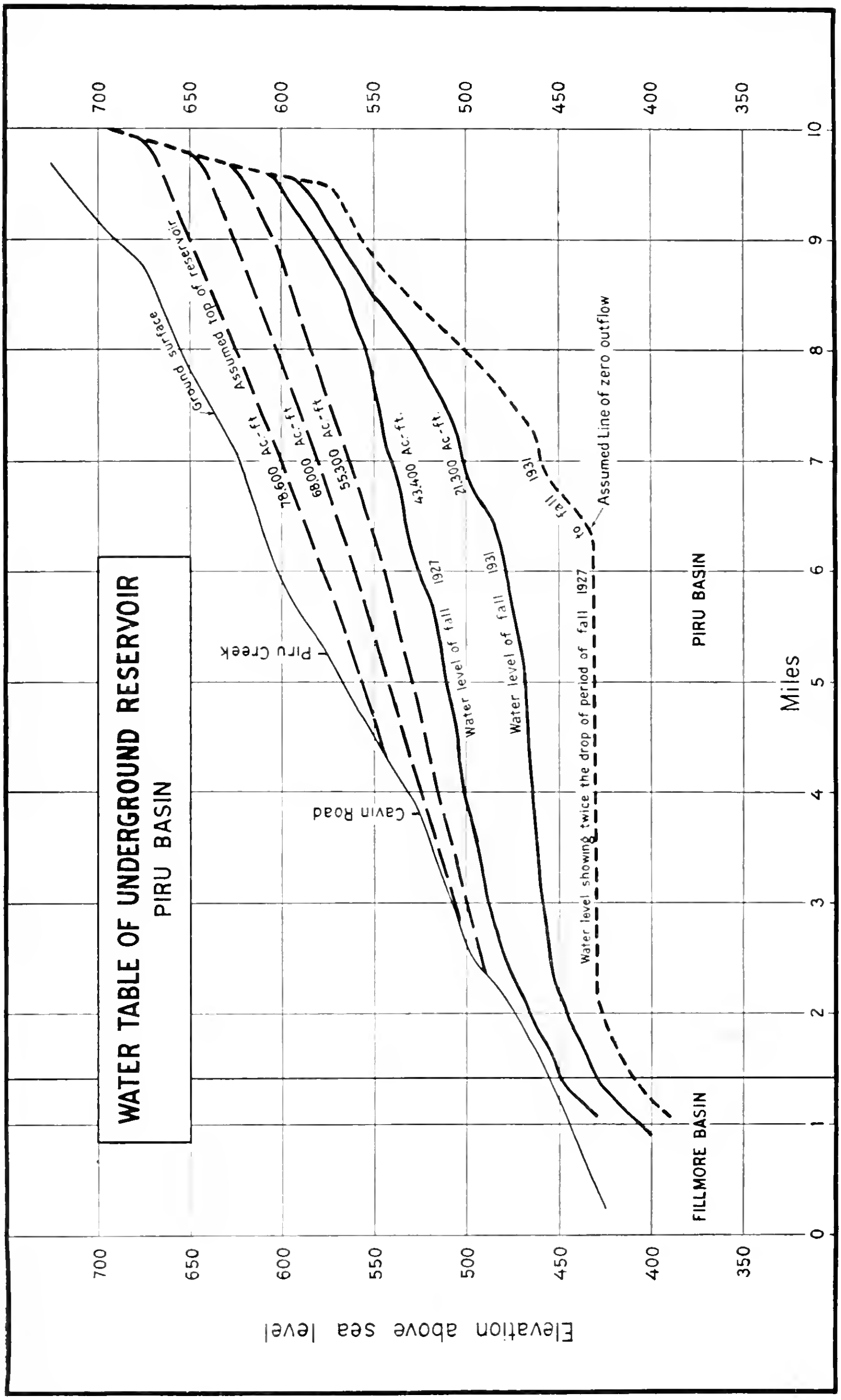
Change in Storage Computations

To compute the change in storage between water tables, isopiestics were drawn for all recorded and hypothetical water tables.

As defined by Meinzer,* an isopiestic line of an aquifer (water-yielding formation) is an imaginary line, all points on which have the same static level. It is a contour of the piezometric surface of the aquifer. A piezometric surface may be an artesian pressure surface, which is above the upper surface of the zone of saturation; a normal-pressure surface, which coincides with the upper surface of the zone of saturation; or a subnormal pressure surface, which is below the upper surface of the zone of saturation. A normal pressure surface is generally the same as the water table. For this report, the storage

* Meinzer, O. E. Outline of Ground Water Hydrology, U. S. Geological Survey, Water Supply Paper 494, pp. 38–39, 1923.

PLATE XX


WATER TABLE OF UNDERGROUND RESERVOIR
PIRU BASIN
Elevation above sea level
Miles
700
650
600
550
500
450
400
350
0
1
2
3
4
5
6
7
8
9
10
Ground surface
Assumed top of reservoir
Assumed Line of zero outflow
78,600 Ac.-ft.
68,000 Ac.-ft.
55,300 Ac.-ft.
43,400 Ac.-ft.
21,300 Ac.-ft.
Water level of fall 1927
Water level of fall 1931
Water level showing twice the drop of period of fall 1927 to fall 1931
Piru Creek
Cavin Road
PIRU BASIN
FILLMORE BASIN

computations were made only for those basins having a normal-pressure surface. Hence, the isopiestics used are contours on top of the zone of saturation.

Computations of change in storage were made for the following basins: Piru, Fillmore, Santa Paula, Oxnard Plain nonpressure area, Ojai Valley and Ventura River. In the other basins the geologic conditions are such and data so meagre that no attempt at computations was made.

The elevations of the water tables at the end of the pumping season were used in computing change in storage. These elevations are termed fall measurements, although they may vary from September to January.

Piru Basin

Computations were made of the change in storage resulting from the lowering of the water table from fall 1927 to fall 1932. The change in storage was as follows:

Period	*Acre-feet*
Fall 1927 to fall 1928	— 4,100
Fall 1928 to fall 1929	— 9,900
Fall 1929 to fall 1930	— 3,800
Fall 1930 to fall 1931	— 4,300
Fall 1931 to fall 1932	+13,400
Net change	— 8,600

A computation was made of the storage capacity between the water table of fall 1931, which is the lowest water level on record, and a hypothetical water table twice as far below the water table of fall 1927 as was the water table of fall 1931. (See Plate XX.) The storage capacity as computed is 21,300 acre-feet, making a total storage capacity below the water table of fall 1927 of 43,400 acre-feet. There is, of course, additional capacity below but this elevation is arbitrarily assumed as bottom of the reservoir.

Hypothetical water tables were drawn for each 20-foot rise above that of spring 1928 at the spreading areas. Storage between the water table of spring 1928 and fall 1927 is computed to be 2200 acre-feet. The storage capacity computed for each successive 20-foot rise is as follows:

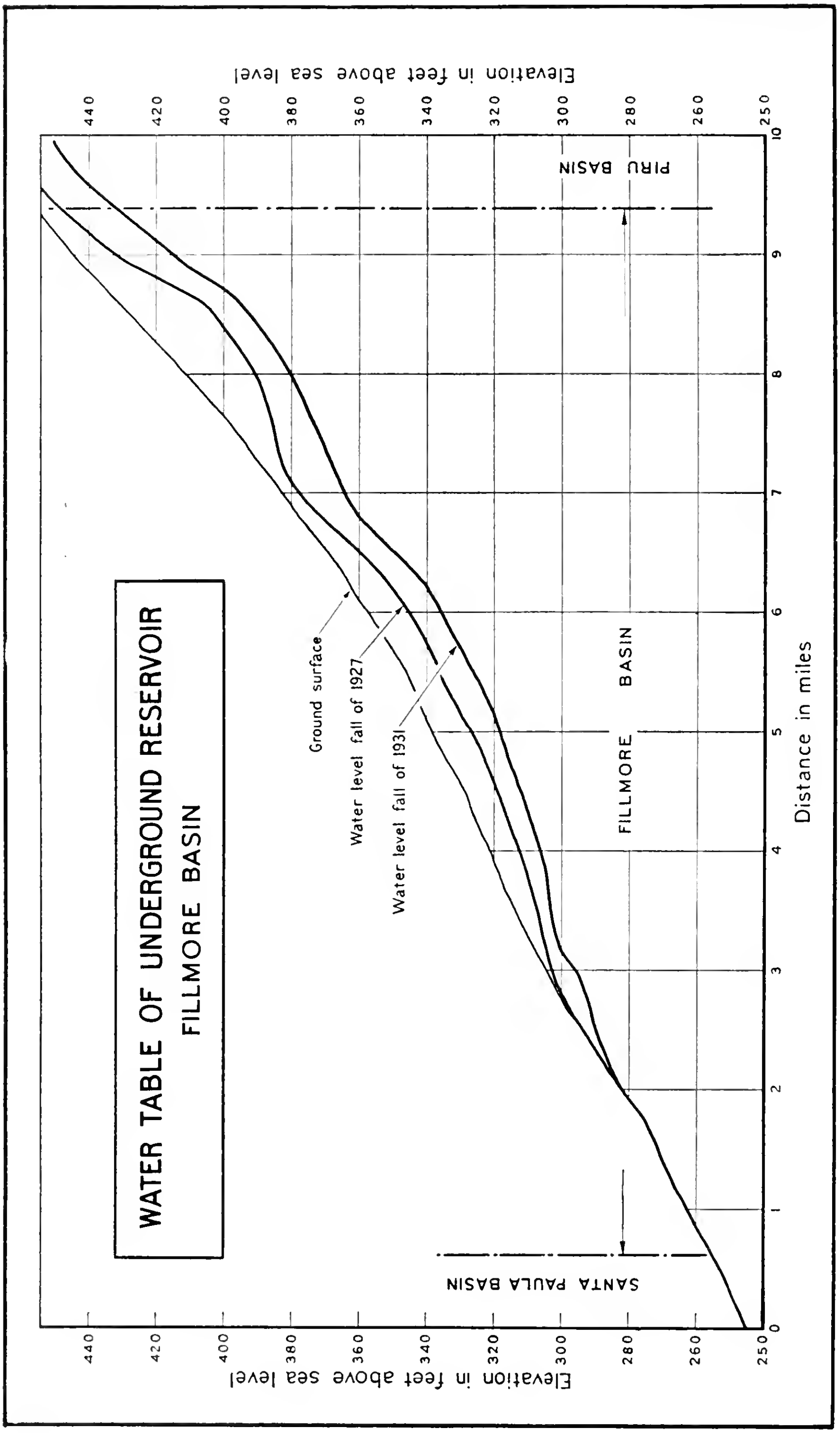
First 20-foot rise	9,700 acre-feet
Second 20-foot rise	12,700 acre-feet
Third 20-foot rise	10,600 acre-feet

In spring 1928 there was an area of rising water extending along the bed of the Santa Clara River from the western boundary of Piru Basin eastward about 2000 feet. It is estimated that for the above hypothetical water levels above the water level of spring 1928 the rising water area would be extended eastward as follows:

Water level	*Distance from western end of Piru Basin*
Spring 1928	2,000 feet
Spring 1928 +20 feet	5,000 feet
Spring 1928 +40 feet	7,000 feet
Spring 1928 +60 feet	15,000 feet

It is believed that if the water table rose higher than 60 feet above the level of spring 1928 the flow of rising water would be so

PLATE XXI


WATER TABLE OF UNDERGROUND RESERVOIR
FILLMORE BASIN
Ground surface
Water level fall of 1927
Water level fall of 1931
SANTA PAULA BASIN
FILLMORE BASIN
PIRU BASIN
Distance in miles
Elevation in feet above sea level
0
1
2
3
4
5
6
7
8
9
10
250
260
280
300
320
340
360
380
400
420
440

great that the storage would not be retained: hence the storage capacity has not been computed for hypothetical water tables above that of spring 1928 at the spreading areas.

A summary of the storage capacities for various intervals in Piru Basin is as follows:

Interval	*Acre-feet*
Above level of fall 1928	35,200
Between level of fall 1928 and fall 1931 (lowest recorded)	22,100
Between level chosen as bottom and level of fall 1931	21,300
	79,000

Plate XX is a longitudinal profile constructed from isopiestic maps and showing various water tables.

Fillmore Basin

Computed change in storage during the period of investigation is as follows:

Fall 1927 to fall 1931	—15,800 acre-feet
Fall 1931 to fall 1932	+ 10,400 acre-feet
Net change	— 5,400 acre-feet

The computed change between the water tables of fall 1927 and spring 1928 was a gain in storage of 5000 acre-feet. The water table of spring 1928 stood within 20 feet of the ground surface along the course of the Santa Clara River through the basin. A small vertical rise of water level above the water table of spring 1928 would cause a large increase in area and volume of rising water.

An estimate of the amount of available storage capacity in Fillmore Basin above the water level of spring 1928 was made by drawing isopiestics coinciding with the ground surface contours along the bed of the Santa Clara River and coinciding, along the borders of the basin, with the isopiestics of equal elevation for spring 1928. The computed storage capacity between this hypothetical water table representing a full basin and the water table of spring 1928 was 12,000 acre-feet giving a total capacity above the fall 1927 level of 17,000 acre-feet. Adding this to the capacity between the fall 1927 and fall 1931 levels gives 33,000 acre-feet. There is of course much capacity below the 1927 level available with small pumping lift. (See Plate XXI.)

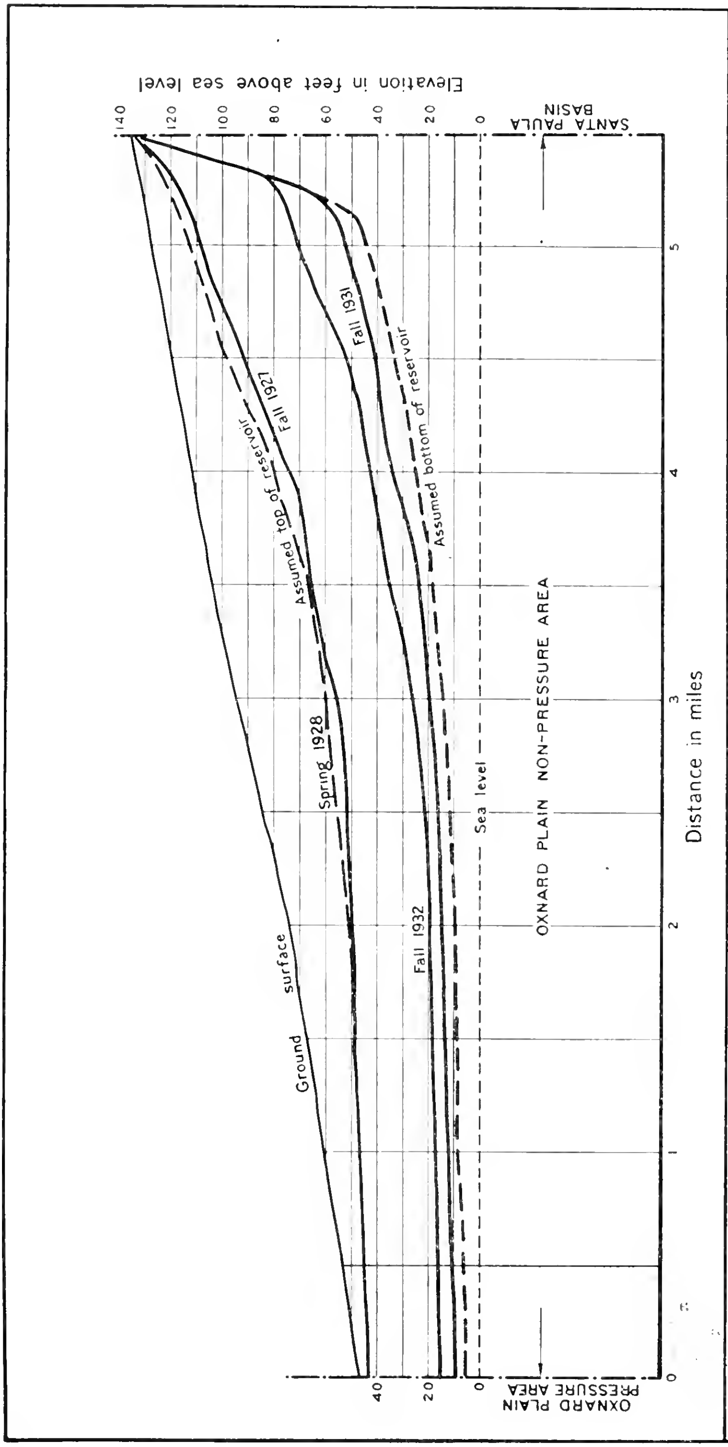
Santa Paula Basin

Computed changes in storage during the period of investigation are as follows:

Period	*Acre-feet*
Fall 1927 to fall 1931	—14,400
Fall 1931 to fall 1932	+ 8,300
Net change	— 6,100

The computed gain in storage of Santa Paula Basin from fall 1927 to spring 1928 was 1900 acre-feet. In spring 1928 there was rising water in Santa Clara River throughout its course through the basin. Any addition of water to the basin above the water table of spring 1928 would increase this flow and hence, there is no practical storage capacity above that water table.

PLATE XXII



WATER TABLE OF UNDERGROUND RESERVOIR
OXNARD PLAIN NON-PRESSURE AREA

The water levels of spring each year coincide with the ground surface at the Santa Clara River channel. During the pumping season there is a slight lowering of the water level below the ground surface in the Santa Clara River channel in the central part of the basin.

Oxnard Plain Nonpressure Area

Computations were made for the Oxnard Plain nonpressure area for the fall water tables of 1927 to 1932 inclusive, and the yearly change in storage computed. Several of the water levels are shown on Plate XXII. The estimated yearly changes in storage from fall 1927 to fall 1932 are as follows:

Period	*Acre-feet*
Fall 1927 to fall 1928	—20,300
Fall 1928 to fall 1929	—26,000
Fall 1929 to fall 1930	—13,800
Fall 1930 to fall 1931	—10,700
Fall 1931 to fall 1932	+13,100
Net change	—57,700

The computed gain in storage from fall 1927 to spring 1928 was 5000 acre-feet. As shown on Plate XXII the water table of spring 1928 was within five feet of the ground surface under the Santa Clara River channel at the dividing line between the pressure and nonpressure area. A slight rise in water level above the level of spring 1928 would cause the ground water to flow as perched water over the artesian area. Hence, there is little available storage capacity above that water table and no attempt has been made here to estimate it.

Ojai Valley

Estimates of change in storage did not appear to check sufficiently with estimates made by other methods and were not used.

No storage space can be counted on above the water table of spring 1928. In fact, the water table of spring 1928 was itself only a temporary high water level. After the heavy rains of winter 1926–27 the water table rose to the ground surface near the city of Ojai, flooding the ditches during the construction of the Ojai sewer system, and rising water drained into the San Antonio Creek at the lower end of the basin.

Upper Ventura River Valley

Because of the smaller number of wells in Upper Ventura River Valley and because of their distribution it was impossible to make reliable computation of change in storage or of total storage.

CHAPTER VI

RAINFALL PENETRATION*

Rainfall is disposed of in four parts, (1) surface run-off, (2) evaporation, (3) transpiration, and (4) percolation. Only the last part passes to the ground water supply. Under ordinary topographic and soil conditions surface run-off will occur when the precipitation is of sufficient intensity. A part of the surface run-off from valley floors may be termed local as it flows directly into depressions and then percolates into the ground without reaching the main surface streams. That portion of the precipitation retained temporarily in the top layer of the soil or intercepted by plants is returned to the atmosphere by evaporation. Of the water which percolates into the ground a portion is stored in the soil within the root zone and subsequently is transpired by plants, while the remainder penetrates below the root zone and joins the ground water. The amount penetrating to ground water may be determined indirectly if values are established for the other factors entering into the disposition of rainfall, since all water penetrating below the root zone and beyond capillary reach of plant rootlets and evaporation must ultimately reach ground water, excepting only moisture lost in the form of vapor due to the circulation of air in the soil below the root zone. This loss is very small and is disregarded in the following discussion.

DESCRIPTION OF SOILS IN VENTURA AREA**

The soils of the Ventura area may be broadly classified in four groups namely, (a) residual soils, or those derived from the disintegration and weathering of consolidated rocks in place; (b) old valley-filling and coastal plains soils, consisting of elevated and weathered unconsolidated water-laid deposits; (c) recent alluvial soils derived from sediments that have not undergone material changes or internal modification since their deposition, and which are still in process of formation; and (d) wind-laid soils, confined to a very narrow belt of drifting sand dunes along the ocean front. Besides these soils, parts of the area are occupied by lands mainly nonagricultural, which are separated from the preceding groups on practical economic grounds rather than on characteristics of origin and mode of formation.

The first three groups comprise the soils of nearly all of the agricultural lands of the State, the residual soils predominating in the mountainous regions, the old valley-filling and coastal plains soils usually being most extensive at lower elevations and along the sea coast, and the recent alluvial soils prevailing on the floors of most of the valleys.

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* By Harry F. Blaney, Irrigation Engineer, Division of Irrigation, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Prepared under the direction of W. W. McLaughlin, Chief of the Division of Irrigation.

** Abstracted in part from Soil Survey of Ventura Area, Bureau of Soils, U. S. Department of Agriculture. (1917.)

The residual soils, which are rather inextensive in this survey, occur principally in the eastern and southeastern parts of the area. The old valley-filling soils are much more extensive than the residual soils, and the recent alluvial deposits far exceed the combined area of the other two. Each of the groups mentioned includes a number of soil series, and each series is represented by one or more soil types.

The residual soils of the area are identified with hilly and mountainous regions and are formed from the weathering of rocks in place. They are associated with rough broken and stony land in many places and have some rock outcrop locally. This group includes the Altamont, Diablo, and Olympic series.

The soils of the old valley-filling and coastal plains group are derived from elevated, unconsolidated, water-laid deposits which have undergone marked changes since they were laid down. The five series belonging in this group are the Rincon, Pleasanton, Ojai, Madera, and Montezuma.

The recent alluvial soils form by far the most extensive group of the area. They cover nearly all of the Santa Clara River fan on the plains in the region about Oxnard, and occur also as river bottom deposits and as numerous alluvial fans lying in the main stream valleys at the mouths of tributary creeks and drainage ways. These soils are classified in three series. Those whose materials come originally from sedimentary rocks and old valley-filling deposits are in the Yolo and the Dublin series and those from deposits washed from areas of basic igneous rocks are in the Vina series. Table 12 shows percentages of different soils in the Ventura area.

TABLE 12

PERCENTAGES OF DIFFERENT SOILS IN VENTURA AREA

Type	Per cent	Type	Per cent
Rough broken and stony land	56.7	Montezuma clay adobe	0.8
Yolo fine sandy loam	7.1	Yolo fine sand	.8
Altamont loam	6.0	Yolo silty clay loam	.8
Rincon loam	3.5	Rincon fine sandy loam	.7
Yolo silt loam	3.3	Vina fine sandy loam	.6
Altamont clay loam	2.4	Altamont stony loam	.6
Yolo loam	2.2	Madera sandy loam	.6
Yolo sand	1.7	Dublin loam	.5
Riverwash	1.7	Pleasanton loam	.5
Yolo gravelly fine sandy loam	1.6	Coastal beach and dunesand	.4
Yolo very fine sandy loam	1.3	Tidal marsh	.3
Rincon clay loam	1.1	Pleasanton gravelly loam	.3
Yolo sandy loam	1.1	Pleasanton gravelly sandy loam	.2
Dublin clay loam	1.0	Olympic clay adobe	.2
Ojai very fine sandy loam	0.9	Altamont clay adobe	.1
Olympic loam	0.9	Diablo clay adobe	.1

SOIL MOISTURE STUDIES IN 1931–32

The penetration of any one season's rainfall depends on the initial moisture conditions in the soil at the beginning of the rainy season and the amount of evaporation and transpiration occurring during that season. These factors vary with the cover, but the area under consideration can be classified according to crops grown. For example, citrus trees are shallow rooted and cause a small initial deficiency of soil moisture in the fall, while deciduous trees and native brush are deep rooted and use the soil moisture to greater depths, thus causing

a large initial fall moisture deficiency. Soil moisture studies are relied upon to determine values for the initial fall moisture condition and subsequent evaporation and transpiration losses. With these factors known, the rainfall penetrating below the root zone can be calculated.

Sixteen rainfall penetration plots were established on typical areas on the valley floors of various subbasins, as indicated in Table 13 and Plate I. Soil moisture conditions at these stations were studied during the period October, 1931, to May, 1932, for the purpose of determining the initial soil moisture deficiency, evaporation-transpiration, field capacity, storage of rain water in the soil and the downward percolation of the water. Soil samples were taken with standard soil-sampling tubes in one-foot sections to depths of from 10 to 17 feet reaching soil conditions well below the major root zone of most native and crop plants. Standard laboratory practices were used in determining the moisture content of the soil samples. Table 14 summarizes the results of soil moisture studies on the rainfall penetration plots.

TABLE 13

DESCRIPTION OF PLOTS SELECTED FOR RAINFALL PENETRATION EXPERIMENTS IN VENTURA COUNTY, 1931-32

Plot No.	Location	Crop	Age, years	Soil type	Annual rainfall 1931-32, inches
A	9.9 mi. NW. of Saticoy	Heavy weeds and grass (nonirrigated)		Yolo silt loam	17.56
B	0.5 mi. N. and 0.5 mi. E. of Simi	Apricots (irrigated)		Yolo fine sandy loam	15.91
C	0.5 mi. S. and 0.3 mi. W. of Moorpark	Walnuts (irrigated)	16	Yolo fine sandy loam	15.72
D	1.8 mi. SE. of Saticoy	Beans (irrigated)		Yolo fine sandy loam	16.55
E	2.2 mi. E. of Ojai	Navel oranges (irrigated)	12	Yolo gravelly fine sandy loam	26.11
F	3.0 mi. W. of Ojai	Apricots (nonirrigated)	6	Ojai very fine sandy loam	24.43
G	0.5 mi. NE. of El Rio	Scattered weeds and grass (nonirrigated)		Yolo fine sandy loam	16.55
H	1.3 mi. S. and 5.0 mi. E. of Saticoy, Las Posas District	Walnuts (irrigated)	15	Yolo silt loam	15.77
I	1.3 mi. NW. of Bardsdale	Walnuts (irrigated)	25	Yolo very fine sandy loam	21.91
J	1.3 mi. NW. of Bardsdale	Navel oranges (irrigated)	10	Yolo very fine sandy loam	21.91
K	1.3 mi. SE. of Piru	Walnuts (irrigated)	16	Yolo fine sandy loam	20.91
L	2.0 mi. SW. of Piru	Navel oranges (irrigated)	10	Yolo gravelly fine sandy loam	21.08
M	0.5 mi. SW. of El Rio	Beans (irrigated)		Yolo fine sandy loam	16.46
N	2.7 mi. NW. of Bardsdale	Walnuts (irrigated)	21	Yolo fine sandy loam	21.75
O	2.5 mi. SW. of Fillmore	Lemons (irrigated)	17	Yolo gravelly fine sandy loam	21.75
P	2.5 mi. SW. of Fillmore	Walnuts (irrigated)	23	Yolo fine sandy loam	21.75

The results of the soil sampling indicate that penetration occurred below the root zone of all the shallow rooted crops, such as citrus and beans, which had been irrigated regularly during the summer months. In areas of sufficient rainfall penetration occurred in irrigated deciduous lands.

TABLE 14

SUMMARY OF RESULTS OF SOIL MOISTURE STUDIES ON RAINFALL PENETRATION PLOTS IN VENTURA COUNTY, 1931-32

Plot No.	Crop	Depth in feet	Field capacity, per cent	Initial soil moisture deficiency in inches	Depth of penetration in feet
A	Grass and weeds (nonirrigated)	0- 6 6-10 0-10	20.6 13.3 ------------	15.1 3.5 18.6	9½
B	Apricots	0- 9 9-11 0-11	12.3 7.2 ------------	6.7 0.0 6.7	No dry soil
C	Walnuts	0- 2 2- 4 4- 8 8-15 0-15	9.7 28.6 6.4 10.0 ------------	3.0 4.4 2.6 0.7 10.7	No dry soil
D	Bare bean land	0- 5	20.1	5.0	Below root zone
E	Oranges	0- 3 3- 6 0- 6	18.1 10.2 ------------	2.1 0.8 2.9	Below root zone
F	Apricots (nonirrigated)	0- 6	17.0	15.6	------------
G	Grass and weeds (nonirrigated)	0- 6 6-10 0-10	14.5 5.0 ------------	10.6 3.3 13.9	9
H	Walnuts	0-15	25.0	9.6	No dry soil
I	Walnuts	0-15	16.0	11.6	No dry soil
J	Oranges	0- 6	18.2	3.7	Below root zone
K	Walnuts	0- 7 7-15 0-15	21.1 4.2 ------------	6.9 1.1 8.0	No dry soil
L	Oranges	0- 6	12.9	2.5	Below root zone
M	Bare bean land	0- 5	15.5	4.1	Below root zone
N	Walnuts	0- 6 6-12 0-12	26.1 16.6 ------------	12.9 —1.8 11.1	No dry soil
O	Lemons	0- 6	15.0	—0.1	Below root zone
P	Walnuts	0- 6 6-12 0-12	12.1 10.0 ------------	7.2 7.8 15.0	No dry soil

Penetration did not occur in the grass and weed areas where the rainfall was less than 20 inches. In grass and weed plots, A and G, the soil was dry to a depth of 17 feet. The results indicate that no rainfall had penetrated below the roots in these plots for at least five years, since the annual rainfall during this period was less than that of 1931–32. The deficiency of soil moisture at the beginning of the rainy season is high, and should not be considered representative of sections receiving greater rainfall.

FACTORS IN RAINFALL DISPOSAL

Initial Soil Moisture Deficiency

As previously suggested, there is at the beginning of almost every rainy season an initial deficiency of soil moisture within the root zone in the district studied. During the summer months the capillary

moisture is more or less completely withdrawn from the soil within the root zone by the processes of evaporation and transpiration. In nonirrigated soil the moisture content may be depleted to the wilting point throughout the greater portion of the root zone, while in irrigated soil, because of the artificial application of water, the moisture content may be much greater. Thus the deficiency of soil moisture below field capacity at the beginning of the rainy season is an important factor in limiting the amount of rainfall penetrating to ground water. Aside from the penetration due to local surface run-off, there can be no material penetration below the root zone until all of the soil within that zone has been supplied with its field capacity. The moisture content of the soil at the beginning of the rainy season varies with the last crop raised, type of soil, amount of irrigation water applied, evaporation, transpiration by plant life, depth of water table and other conditions. Citrus trees are shallow-rooted and their effect upon initial deficiency of soil moisture is small, while grape vines, deciduous trees, and native brush are deep rooted and draw from the soil moisture to greater depths, thus causing greater moisture deficiencies.

The initial fall deficiency in moisture content of the soil is determined as follows:

Soil samples are taken previous to the beginning of the rainy season and again later when the soil is at its field capacity, either as the result of rainfall or irrigation. The moisture content of these soil samples is determined by standard methods. The difference between the moisture content of the soil at field capacity and initial moisture content in the fall of the year is equal to the initial fall deficiency of soil moisture.

This method was used to determine the initial soil moisture deficiency at the sixteen rainfall penetration plots previously described. Similar soil moisture data were obtained from the Santa Paula Citrus Fruit Association, Sespe Ranch, and Limoneira Ranch, and the initial soil moisture deficiency was calculated. The results are summarized in Table 15.

After considering many other observations made in southern California during the past five years, the values shown in Table 16 are taken as representative of Ventura area conditions, and are used in computing rainfall penetration.

Run-off

Hydrographers making the Ventura investigations have determined the rate of run-off on certain known areas. A part of the surface run-off from the valley floors may be termed local as it flows directly into the depressions and percolates into the ground without reaching the main surface streams. Of the five rainfall seasons studied, that of 1931–32 was the only one having sufficient rainfall to cause measurable run-off from the valley floors into the main river channels, and such run-off is thought to be limited to the two basins having the highest rainfall, Ojai Valley and Ventura River. The run-off from the rainfall during the 1931–32 season is estimated to be 1.4 inches for the penetration area in Ojai Valley and 1.6 inches in Ventura River Basin.

TABLE 15

SUMMARY OF INITIAL SOIL MOISTURE DEFICIENCY DATA IN VENTURA COUNTY, 1931

Number	Location	Soil type	Crop	Initial deficiency in inches
		Citrus Irrigated Usual Practice		
3	1 mi. NE. of Somis	Rincon fine sandy loam	Oranges	2.3
4	½ mi. NE. of Somis	Rincon fine sandy loam	Oranges	3.3
7	2 mi. W. of Piru	Heavy type Yolo loam	Oranges	3.7
12	1 mi. W. of Santa Paula	Yolo silt loam and Yolo loam, gravelly series	Lemons	3.1
13	1 mi. N. of Santa Paula	Yolo series, badly mixed, some gravel	Lemons	2.8
15	3 mi. W. of Santa Paula	Heavy textured Yolo silt loam	Lemons	1.9
16	2 mi. W. of Santa Paula	Yolo gravelly loam	Lemons	3.2
17	8 mi. E. of Santa Paula	Several soil types, Yolo gravelly loam, some Rincon loam	Lemons	2.3
18	3 mi. W. of Santa Paula	Yolo silt loam, some gravel	Lemons	3.5
19	4 mi. E. of Santa Paula	Yolo silt loam or Yolo fine sandy loam	Lemons	1.5
21	6½ mi. W. of Santa Paula	Yolo silt loam, some gravel	Oranges	2.8
22	6 mi. W. of Santa Paula	Yolo silt loam	Lemons	2.1
24	2½ mi. W. of Santa Paula	Yolo loam some gravel, some Rincon loam	Lemons	2.8
25	2 mi. W. of Santa Paula	Yolo fine sandy loam, Yolo loam	Lemons	1.8
26	1 mi. E. of Ventura	Yolo loam, heavy texture	Lemons	2.7
27	½ mi. E. of Saticoy	Yolo fine sandy loam	Oranges	1.8
28	2½ mi. E. of Santa Paula	Yolo gravelly fine sandy loam	Lemons	1.7
30	5 mi. E. of Ventura	Yolo silt loam	Oranges	2.0
31	5 mi. E. of Ventura	Yolo fine sandy loam, some rock and gravel, very fine soil	Lemons	3.5
32	2 mi. W. of Fillmore	Yolo fine sandy loam, gravelly type	Lemons	2.0
34	2 mi. W. of Santa Paula	Yolo silt loam, fine type	Lemons	2.1
E	2.2 mi. E. of Ojai	Yolo gravelly fine sandy loam	Oranges	3.0
J	1.3 mi. NW. of Bardsdale	Yolo very fine sandy loam	Oranges	3.7
L	2 mi. SW. of Piru	Yolo gravelly fine sandy loam	Oranges	2.5
35	Sespe Ranch, Fillmore	Rincon loam over red clay	Oranges	3.3
36	Sespe Ranch, Fillmore	Yolo fine sandy loam	Oranges	2.9
37	Sespe Ranch, Fillmore	Yolo fine sandy loam	Oranges	1.3
39	Sespe Ranch, Fillmore	Yolo loam	Oranges	3.5
42	Sespe Ranch, Fillmore	Yolo silt loam	Oranges	1.0
43	Sespe Ranch, Fillmore	Yolo fine sandy loam	Oranges	3.4
44	Sespe Ranch, Fillmore	Yolo fine sandy gravelly loam	Oranges	2.3
46	Sespe Ranch, Fillmore	Yolo gravelly loam	Oranges	1.3
		Citrus Irrigated Just Prior to Nov. 1, 1931		
5	2 mi. W. of Piru	Yolo fine sandy loam	Oranges	—1.0
6	Piru District	Yolo fine sandy loam	Oranges	—0.2
8	2 mi. W. of Santa Paula	Yolo fine sandy loam	Lemons	1.0
9	2 mi. W. of Santa Paula	Yolo silt loam, gravelly type	Lemons	0.0
20	7 mi. W. of Santa Paula	Rincon fine sandy loam	Oranges	0.8
O	2.5 mi. SW. of Fillmore	Yolo gravelly fine sandy loam	Lemons	—0.1
38	Sespe Ranch, Fillmore	Yolo fine sandy loam	Oranges	0.5
40	Sespe Ranch, Fillmore	Yolo fine sandy loam	Oranges	0.8
41	Sespe Ranch, Fillmore	Yolo fine sandy loam	Oranges	0.7
45	Sespe Ranch, Fillmore	Yolo gravelly loam	Oranges	0.2
		Deciduous Irrigated		
H	1.3 mi. S., 5 mi. E. of Saticoy	Yolo very fine sandy loam	Walnuts	9.6
I	1.3 mi. NW. of Bardsdale	Yolo very fine sandy loam	Walnuts	11.6
K	1.3 mi. SE. of Piru	Yolo fine sandy loam	Walnuts	8.0
N	2.7 mi. NW. of Bardsdale	Yolo fine sandy loam	Walnuts	11.1
P	2.5 mi. SW. of Fillmore	Yolo fine sandy loam	Walnuts	15.0
B	½ mi. N., ½ mi. E. of Simi	Yolo fine sandy loam	Apricots	6.3
C	½ mi. S., 0.3 mi. W. of Moorpark	Yolo fine sandy loam	Walnuts	10.8

TABLE 16

INITIAL SOIL MOISTURE DEFICIENCIES USED IN RAINFALL PENETRATION CALCULATIONS IN VENTURA COUNTY

Type of land	Initial soil moisture deficiency, in inches
Citrus (irrigated just prior to rainy season)	½
Citrus (irrigated usual practice)	2½
Deciduous trees and vineyard	10
Truck and miscellaneous (irrigated)	3
Beans (irrigated)	4
Beans (nonirrigated)	6
Grain (irrigated)	3
Grain (nonirrigated)	7
Grass, weeds and brush	10
Bare land and river-wash	3

Evaporation and Transpiration

Evaporation loss after a rainstorm is influenced by many factors such as temperature, wind movement, soil type, kind of vegetation, interception, periods between storms, etc. Observations made in southern California during the past five years indicate that the average evaporation loss from the top soil is about one-half acre-inch per acre after each rainstorm.*

After careful consideration of all data collected from cooperative irrigation investigations made since 1926 in southern California, the average transpiration for the winter period for all active growing agricultural crops is taken as 1 acre-inch per acre per month.** Investigations have shown that bare land and vineyards and deciduous orchards that are clean cultivated have no material transpiration loss during the winter period.

Studies in the Santa Ana River Valley show the average winter evaporation-transpiration rate per 30 days for grass and weeds to be 2 inches, and for brush 2.4 inches. Observations made on grass and weeds near Santa Paula during the winter of 1931–32 confirmed these values.

CALCULATIONS

For the purpose of completing the hydraulic accounting in this report, an estimate has been made of the contribution of rain falling on the valley floor to the ground water supply for the rainy seasons 1927–28 to 1931–32, inclusive. The locations of the thirteen basins considered are shown on Plate I.

The same total seasonal rainfall may give entirely different penetration due to varying intensity and distribution of storms. Winter irrigation also varies with the season and influences the amount of penetration.

Rainfall records from thirty stations were used, usually several records being available in each basin. Computations were made for each rainfall station and the average of the stations taken as the penetration for the basin.

* Bulletin No. 33, Division of Water Resources, "Rainfall Penetration and Consumptive Use of Water in Santa Ana River Valley and Coastal Plain."
Bulletin No. 19, Division of Water Resources, "Santa Ana Investigation."
** Bulletins Nos. 19 and 33, *supra*.

The calculations may be divided into two divisions: those for determination of penetration of rainfall in inches for various crop, cover and land classifications, and those for the determination of the total amount of penetration in acre-feet.

Under the first of these, values for initial soil moisture deficiency, run-off, evaporation and transpiration losses, previously given, have been used. These were analyzed by months and deducted from the rainfall. The remainder is considered to penetrate below the root zone and eventually reach the ground water. Assumptions are for average soil conditions. An example of detailed calculations of rainfall penetration for one station is given in Table 17.

TABLE 17

AN EXAMPLE OF DETAILED CALCULATIONS OF RAINFALL PENETRATION IN INCHES AT STATION 83, 1931-32*

Factors	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total	Crop
Rainfall		2.6	7.8	1.7	5.2	0		Citrus, clean cultivated, irrigated usual practice
Run-off		0	0	0	0	0		
Transpiration		1.0	1.0	1.0	1.0	1.0		
Evaporation		1.0	1.9	1.4	1.5	0		
Difference		.6	4.9	—.7	2.7	—1.0		
Soil moisture deficiency	2.5	1.9	0	.7	0	1.0		
Penetration			3.0		2.0		5.0	
Rainfall		2.6	7.8	1.7	5.2	0		Citrus, clean cultivated, irrigated just prior to rainy season
Run-off		0	0	0	0	0		
Transpiration		1.0	1.0	1.0	1.0	1.0		
Evaporation		1.0	1.9	1.4	1.5	0		
Difference		.6	4.9	—.7	2.7	—1.0		
Soil moisture deficiency	0.5	0	0	.7	0	1.0		
Penetration		.1	4.9		2.0		7.0	
Rainfall		2.6	7.8	1.7	5.2	0		Deciduous, clean cultivated
Run-off		0	0	0	0	0		
Transpiration		0	0	0	0	0		
Evaporation		1.0	1.9	1.4	1.5	0		
Difference		1.6	5.9	.3	3.7	0		
Soil moisture deficiency	10.0	8.4	2.5	2.2	0	0		
Penetration					1.5		1.5	
Rainfall		2.6	7.8	1.7	5.2	0		Deciduous, cover cropped
Run-off		0	0	0	0	0		
Transpiration		0	0	1.0	1.0	1.0		
Evaporation		1.0	1.9	1.4	1.5	0		
Difference		1.6	5.9	—.7	2.7	—1.0		
Soil moisture deficiency	10.0	8.4	2.5	3.2	.5	1.5		
Penetration							0	

*Total seasonal rainfall, 17.54 inches. No winter irrigation.

Run-off from the valley floors into the main surface streams was considered negligible except for the Ojai Valley and Ventura River Basin during the 1931–32 season, as previously stated.

The deficiency of soil moisture at the beginning of the rainy season varies considerably depending primarily upon the last crop grown. The values used in the computations are shown in Table 16.

Evaporation loss for each month was computed from daily rainfall records on the basis of one-half inch loss after each storm.

The transpiration loss for all active growing agricultural crops was taken as 1 inch per month for the winter period. This loss was deducted for cover crops beginning with January. Transpiration loss for bare land and vineyards and deciduous orchards that are clean cultivated was considered negligible during the winter period. For native vegetation, evaporation and transpiration losses were combined

at the rate of 2 inches per month for grass and weeds and 2.4 inches for brush provided sufficient rain fell to meet their demands. In the case of grass and weeds, no transpiration is charged until two weeks after the first effective rain.

The effect of irrigation during the rainy season upon rainfall penetration was estimated from records available. Such irrigation will increase the moisture content of the soil and may increase rainfall penetration. At the same time, considerable irrigation water may penetrate with the rainfall and should be classed as return water.

A summary of calculations of rainfall penetration in inches in each basin for the various classifications and the five seasons studied is given in Table 57, opposite page 200. This completes the first part of the computations.

As previously stated, the second part of the computations consists of determining the total rainfall penetration in acre-feet for each basin. The penetration in inches for each crop, cover and land classification is multiplied by the area. The results reduced to acre-feet are summarized in Table 18 for each basin and season.

TABLE 18

ESTIMATED RAINFALL PENETRATION BELOW ROOT ZONE IN ACRE-FEET*

Basin	1927–28	1928–29	1929–30	1930–31	1931–32
Piru	860	1,170	1,750	1,700	5,050
Fillmore	890	2,650	2,550	2,950	8,270
Santa Paula	320	680	950	900	4,770
Montalvo, North	150	340	470	520	1,740
Montalvo, South	290	720	900	850	3,310
Subtotal	2,510	5,560	6,620	6,920	23,140
West Las Posas	130	400	620	470	1,940
Pleasant Valley	80	520	520	530	3,430
Las Posas (Moorpark)	320	710	790	780	4,980
Conejo (Santa Rosa)	180	240	190	370	460
Simi	370	460	320	580	1,600
Subtotal	1,080	2,330	2,440	2,730	12,410
Ojai Valley	120	50	310	200	2,120
Ventura River	620	710	570	710	3,900
Ventura Avenue	220	240	250	310	1,600
Subtotal	960	1,000	1,130	1,220	7,620
Grand total	4,550	8,890	10,190	10,870	43,170

*Computed by the Division of Water Resources from data in this chapter and other information.

CHAPTER VII

QUALITY OF WATER*

This report is based on the analyses of 1580 samples of water from 440 locations within the area. The analyses were made in three different laboratories, and consequently the methods of analysis used and the constituents reported were not always the same. In tabulating the analytical results the aim has been to obtain such uniformity as could be achieved by recomputation without sacrificing essential accuracy. Of the analyses reported 1117 are classed as complete and 463 as partial. The distinction between these two classes is, of necessity, somewhat arbitrary. In general those classed as complete include the determination of sulphate, calcium, and magnesium as well as bicarbonate and chloride. Some of the complete analyses include also conductance and/or boron determinations. Many of the partial analyses also include conductance and boron but not the sulphates, calcium, and magnesium.

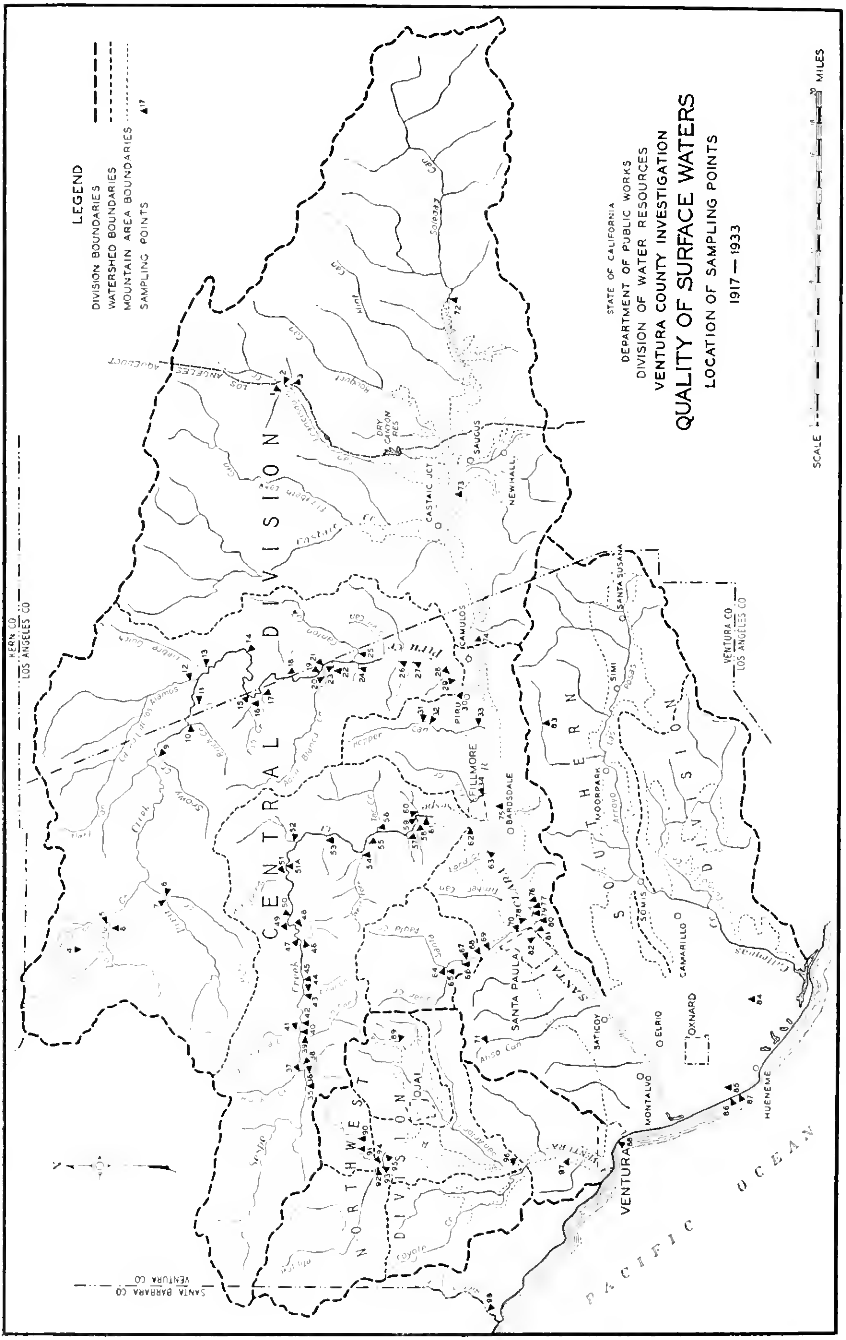
The waters of the Ventura area, both surface and underground, have certain general characteristics in common. These are: (1) relatively high proportions of bicarbonate and sulphate; and (2) relatively low sodium percentages, i. e., high calcium and magnesium. This means that a substantial part of the soluble material consists of calcium together with bicarbonate and sulphate. These constituents form salts of such low solubility that the salts are precipitated from the soil solution in the soil before their concentrations becomes high enough to be injurious to crop plants. The fact that the dominant constituents of these waters form salts of low solubility makes it possible to use successfully for irrigation, waters having much higher total salinity than it would be safe to use if the proportions of either sodium or chloride were higher.

Boron is found in potentially injurious concentrations in a few wells and springs and particularly in the waters of Piru and Sespe Creeks. Some crop injury from boron has occurred in areas contiguous to these sources of boron contamination. Elsewhere in the area evidences of boron injury are either very slight or altogether absent. Recognition of the causes and symptoms of boron injury should make it possible to diminish its extent and seriousness by eliminating some of the sources of contamination, and by so blending the waters of the remaining sources with those of lower boron content as to reduce the boron concentration of the general supply below the limit of tolerance, which for this area is thought to be 0.50 p.p.m.

It should be kept in mind that the sulphate constituent is the dominant one in the waters of the Ventura area and that although much of it may be precipitated from solution as calcium sulphate

* By Carl S. Scofield, Principal Agriculturist in charge of Division of Western Irrigation Agriculture, U. S. Bureau of Plant Industry.

PLATE XXIII



STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
QUALITY OF SURFACE WATERS
LOCATION OF SAMPLING POINTS
1917—1933
LEGEND
DIVISION BOUNDARIES
WATERSHED BOUNDARIES
MOUNTAIN AREA BOUNDARIES
SAMPLING POINTS
SCALE
MILES
CENTRAL DIVISION
SOUTHERN DIVISION
NORTHWEST DIVISION
PACIFIC OCEAN
KERN CO
LOS ANGELES CO
VENTURA CO
LOS ANGELES CO
SANTA BARBARA CO
VENTURA CO
VENTURA
OJAI
SANTA PAULA
FILLMORE
PIRU
CAMULOS
BARDSDALE
SATICOY
MONTALVO
EL RIO
OXNARD
HUENEME
CAMARILLO
SOMIS
MOORPARK
SIMI
SANTA SUSANA
CASTAIC JCT
SAUGUS
NEWHALL
DRY CANYON RES
LOS ANGELES AQUEDUCT

without injury to crop plants, some of it may remain in solution as sodium or magnesium sulphate and thus become sufficiently concentrated in the soil solution to be harmful to crop plants. Such concentration has occurred in some areas in the Oxnard Plain, and to a limited extent elsewhere in the area. The aggregate quantity of sulphate carried annually to the land in the irrigation water is very large, and consideration should be given to the problem of disposing through drainage outlets of that part of it that is not precipitated in the soil as calcium sulphate.

In each of the three drainage subdivisions of the Ventura area there are rather wide ranges of concentration both as to salinity and boron. By far the larger volume of the irrigation water is of the intermediate class with the percentage of sodium ranging below 40, the sulphate content ranging from 300 p.p.m. to 800 p.p.m., and the boron content ranging below 0.5 p.p.m. Water of this type appears to be quite safe for general irrigation use with the existing conditions of climate and soil. There are limited supplies of water of lower salinity and also some of higher salinity than this intermediate class.

There does not appear to be any evidence that the deeper underground waters used for irrigation in the coastal plain sections are more concentrated than those found in some of the upper basins. Nor is there evidence of salt water intrusion to any significant extent along the ocean front of the coastal plain. There is some excessive salinity in the waters found in the subsoil in or just below the root zone in certain areas of the coastal plain, which indicates the need of drainage. The removal of this saline subsoil water is called for not only to protect the productivity of the overlying soil but also to prevent the contamination of the underlying supplies of irrigation water which might occur as the result of temporary or local overdrafts due to excessive pumping from the deeper strata.

SURFACE WATERS

The area included in the Ventura County investigation involves chiefly the drainage basin of the Santa Clara River together with the basin of Calleguas Creek and its tributaries south of the Santa Clara and the basin of Ventura River, which is west of the Santa Clara. All three streams discharge into the Pacific Ocean across the coastal plain of Ventura County. The boundaries of these drainage basins and the locations of the 98 points at which samples of surface water have been taken for analysis are shown on Plate XXIII.

Rincon Creek is a small stream draining the foothills to the west of the drainage area of Ventura River. It was sampled at location 98 in January, 1929. Its water at that time was of low salinity, with low boron and low per cent sodium.

The surface waters of Ventura River and its tributaries have been sampled at nine points. The samples from locations 89, 90, 96 and 97 are characteristic of the better surface waters of this area, having low to intermediate salinity, low boron contents, and low sodium percentages. The sample from Wheeler's Hot Springs, location 91, is essentially different in character. While its salinity is intermediate (conductance 157), its boron content of 6.79 p.p.m. is very high as is its percentage of sodium. Also its chloride content of 241 p.p.m. is very high for that area, while its sulphate content is low. The contrast in

quality between the water of Wheeler's Hot Springs and that of Matilija Hot Springs is very striking. The salinity of the latter is very low as is the boron content, although the sodium percentage is high.

The evidence from the six sampling locations, 90 to 95, shows that while the North Fork of Ventura River above Wheeler's Hot Springs does not contain much boron, it is contaminated with this element from those hot springs. On the other hand, Matilija Creek above Matilija Hot Springs is contaminated with boron, and its concentration is only slightly diluted by the contributions of water from Matilija Hot Springs and from the North Fork, as is shown by the sample from location 95. The samples from Ventura River at Foster Park, location 96, range in conductance from 99.8 to 111, in boron content from 0.41 to 0.52 p.p.m. and in per cent sodium from 9 to 30. While this boron content approaches the lower limit of tolerance, the other characteristics of the river water as sampled at this point are such as to indicate that it is safe for irrigation use.

Santa Clara River drains a mountain watershed most of which lies north of the main river channel. This channel is normally dry except at flood time or except at a few points where subsurface barriers force the underflow to the surface. One such subsurface barrier occurs at location 74. The stream flow as sampled at this point, eleven times during a three-year period, has ranged in conductance from 107 to 205, in boron from 0.26 to 0.70 p.p.m., and in per cent sodium from 19 to 50. The water is characteristically high in bicarbonate and sulphates but low in chlorides. The highest salinity and boron occurred in the low summer flow of 1929.

The surface waters above this point are represented by samples from five locations, one at the mouth of Soledad Canyon, No. 72; three from near the headwaters of San Francisquito Creek; and one, No. 73, from a slough adjacent to the main channel. The samples from locations 1, 2 and 72 are of low salinity and low boron; those from locations 3 and 73 are of intermediate salinity. There is no evidence of serious boron contamination above location 74 at the Newhall ranch bridge.

Shortly below this point the main channel of the river is joined by Piru Creek. This stream is one of the two more important tributaries of the Santa Clara. The quality of its contribution is shown by the analyses of 48 samples from location 29, and 11 samples from location 30, taken during the years 1928 to 1932, inclusive. It will be observed that the discharge at the time of sampling has varied between wide limits and that in general the salinity and the boron content vary inversely as the discharge. The range of conductance is from 51.9 to 363, and of boron content from 0.67 to 3.08 p.p.m. The per cent sodium is generally low as is the chloride content when compared with the bicarbonate and sulphate concentrations. In general, except during flood periods, the water of Piru Creek contains more than 1.5 p.p.m. of boron, a concentration rather too high for safe use in the irrigation of citrus crops, walnuts, and similar boron-sensitive species.

In view of the fact that Piru Creek contributes a substantial part of the water supply of Santa Clara River and that the boron concentration of its water is high, a number of water samples were collected from points along the main stream and from its more important tributaries. The locations of these sampling points, Nos. 4 to 28, inclusive, are shown on the map, Plate XXIII. From these analytical data it is evident that

boron contamination is contributed to the headwaters of the stream by Seymour Creek and Lockwood Creek, both of which drain Lockwood Valley. In this valley and particularly along its north side there are outcrops of boron minerals, chiefly colemanite, which on weathering yield boron salts. However, it is apparent also that not all of the boron found in Piru Creek is derived from Lockwood Valley. The waters contributed by Agua Blanca Creek and several smaller streams below it also contain relatively high concentrations of boron.

In view of the fact that boron and salinity constituents are contributed from several different areas within the watershed of Piru Creek, it is not regarded as feasible to improve the quality of its water by attempting to segregate these sources of contamination. Any program of development by which the flood waters of the stream could be conserved by storage would doubtless result in measurable improvement by dilution, but the character of the soil of the watershed is such that even under the best system of water control the annual yield of salinity and boron must be relatively high.

There are two small creeks that discharge into the Santa Clara between Piru Creek and Sespe Creek. These are Hopper Creek and Pole Creek, locations 31 to 34, inclusive. The waters of both creeks are relatively high in salinity but not in boron.

Sespe Creek, like Piru Creek, drains an extensive area of mountain watershed. The determination of the quality of the water it contributes to the main stream is based on the analyses of 50 samples collected at location 59 during a period of $4\frac{1}{2}$ years. In general the water of Sespe Creek is less saline than that of Piru Creek and contains much less sulphate. On the other hand, it has higher concentrations of both boron and chloride. Its chloride content is generally well below the limit of tolerance for irrigation use but its boron content, which often ranges above 2.5 p.p.m., is definitely too high for safe use for all but the more boron-tolerant crops.

An exploration of Sespe Creek from near its headwaters to its mouth was made in the spring of 1930, locations 35 to 58, inclusive, and 60 and 61. The results of this exploration show that substantially all of the boron is contributed from Willet Warm Springs, location 49, and by Hot Springs Creek, location 51, each having more than 6.0 p.p.m. of boron. If it were found practicable to segregate these spring waters and prevent them from entering the main stream, a very definite improvement in quality should result. It might well be that such segregation would reduce the boron content of Sespe Creek water to a concentration well below the safe limit of tolerance for general irrigation use. The quality of the water contributed by Lord Creek, location 63, is very good.

Conditions along Santa Paula Creek are reported for seven locations, Nos. 64 to 70, inclusive. With one exception the waters from these locations are of good quality. The exception is a spring at location 66. This spring water is high in salinity and in boron, conductance 809, boron 3.58 p.p.m. but the volume of discharge is small. There is a similar spring near the head of Aliso Canyon, location 71, conductance 735, boron 5.76 p.p.m. This latter spring may be responsible, in part, for some of the boron injury to be observed in lemons growing on the delta of Aliso Canyon below the spring.

Along the main channel of Santa Clara River samples have been collected from time to time at eight locations. Nos. 75 to 82, inclusive, from Bardsdale bridge, above the junction of Sespe Creek, to Willard bridge below the junction of Santa Paula Creek. Two of these locations represent oil field drains, and the waters are high in salinity, particularly in chloride, and contain between 1 and 2 p.p.m. of boron. The samples of river water are generally of intermediate salinity, i.e., conductance ranging up to 160, with boron concentrations frequently ranging up to 0.8 p.p.m. or slightly higher. Water of this boron concentration is not well suited for irrigation use on lemons or walnuts.

In the watershed of Calleguas Creek south of the Santa Clara Valley only one sample of surface water has been reported, that from location 83. This water is of good quality both in respect to salinity and boron. On the coastal plain south of Oxnard samples of drainage water have been collected periodically at locations 84 and 85. These drainage waters probably represent the excess soil solution drawn from the root zone of the soil in saline areas. The total salinity is high, as is also the boron. For purposes of comparison the analysis is reported for a sample of ocean water taken from the beach at location 87.

UNDERGROUND WATERS

Ventura River Basin*

For convenience in considering the quality of its underground waters the Ventura River Basin is subdivided into three districts: (1) the Ojai Valley, (2) Ventura Valley above Foster Park, and (3) Ventura Valley below Foster Park. In the Ojai Valley water samples have been analyzed from ten wells. For irrigation purposes the quality of these waters is very good. The conductance has been reported for only one location, 9–L–5, for which it ranges from 72.6 to 76.8; the boron content ranges from 0.02 to 0.17 p.p.m. except in one case where 0.52 p.p.m. is reported. The per cent sodium ranges from 3 to 40, the chloride from 10 to 95 p.p.m., and the sulphate from 72 to 197 p.p.m.

In the Ventura River Valley above Foster Park water samples have been analyzed from eight locations. The ranges in composition are as follows: Conductance (5 only), 110 to 229; boron, 0.10 to 1.44 p.p.m.; per cent sodium 7 to 43; chloride, 40 to 202 p.p.m.; and sulphate, 73 to 606 p.p.m. The highest salinity is found at location 7–M–3 and the highest boron contents at 6–K–2 and 6–K–3. Water from the last named two locations is rather too high in boron for safe use on citrus or walnuts. These wells are located near the head of the valley not far below Wheeler Hot Springs, and their boron contamination may be derived from that source.

In the lower Ventura Valley water samples are reported from only two wells. These are both in the lower end of the valley, and the concentrations are high both in respect to salinity and boron. Their concentrations are: conductances 331 and 501, boron 1.19 and 1.34 p.p.m., per cent sodium 39 and 44, chloride 620 and 1260 p.p.m., sulphate 510 and 538 p.p.m. These concentrations, particularly the high chlorides, suggest that the underground waters of this lower part of the valley may be contaminated either from the ocean or from adjacent oil fields. These waters are both rather too saline to be safe for irrigation use.

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* See Plate XLVI in rear pocket.

Santa Clara River Basin*

The underground waters of the Santa Clara River Basin are here placed in six groups as follows: (1) Shallow test wells of the Oxnard Plain; (2) deep wells of the Oxnard Plain; (3) deep wells of the Montalvo Basin; (4) deep wells of the Santa Paula Basin; (5) deep wells of the Fillmore Basin; and (6) deep wells of the Piru Basin. The Oxnard Plain has been formed by the deposition of sediments largely derived by erosion from the drainage area of Santa Clara River, although Calleguas Creek has contributed substantially to its southern section. These sediments are somewhat stratified and include beds of sand and gravel, through which water moves easily, interspersed or interrupted by strata or barriers of fine silt or of cemented material. These beds of water-bearing sand and gravel are tapped by deep wells and are replenished in part by flood waters from the two streams and in part by subsurface waters moving in a downstream direction along the stream channels.

The bedding of the sediments is such that some of the buried gravel strata appear to be connected with the gravels of the stream channels so that replenishment is but slightly impeded, while the alternating beds of fine silt or of cemented material impede normal hydrostatic equilibrium. Thus the waters found in the buried gravels under the lower or coastward areas of the Oxnard Plain are normally under some hydrostatic pressure, and when these are tapped by wells the water rises nearly to or even above the ground surface. The pressure developed and the consequent elevation of the static water levels are influenced by the volume of replenishment from the contributing stream channels and by the volume of withdrawal through the wells. Thus the static levels are markedly high during the late winter and early spring when the rate of replenishment is high and the rate of withdrawal for irrigation is low.

These conditions have a direct relationship with a discussion of the quality of the water in the Coastal Plain sediments because the evidence indicates that the water supplies chiefly drawn upon for irrigation use are derived directly from the contributing streams and are in consequence of the same quality. In certain areas of the Oxnard Plain surplus water occurs in the subsoil in or just below the root zone. In general this superficial subsoil water is not connected hydrostatically with the water in the deeper gravels, although there may be some situations in which such connection exists. This superficial subsoil water probably represents the local accumulations of rainfall or of surplus irrigation water rather than the rising of water from the deeper gravels.

Analyses were made of water samples from 15 of these shallow subsoil waters of the Oxnard Plain. Because the conductances are not reported for these samples the concentrations of chloride may be taken as the best single measure of salinity. In all the analyses the concentration of sulphate is much higher than that of the chlorides. This may be taken as evidence that the salinity found in these waters is due to concentration by evaporation of the terrestrial waters and not to contamination by sea water. If sea water contamination were involved,

* See Plate XLV in rear pocket.

the chloride content would be higher than the sulphate. Of the 15 samples reported, only four have chloride concentrations below 100 p.p.m. and only two have sulphate concentrations below 600 p.p.m. Thus it is clear that this superficial water is much more saline than the water from the deeper gravels. Its boron content is also much higher, there being only three samples having less than 1.0 p.p.m. of boron.

The difference in quality between the superficial and the deep water is strikingly shown by comparing the analyses of samples from adjacent deep and shallow wells, e.g., 6–R–1 and 7–R–1; 7–U–2 and 8–U–18; 9–U–1 and 9–U–45. These are shown in the following table:

TABLE 19

COMPARISON OF SUPERFICIAL AND DEEP WATER IN OXNARD PLAIN

	(Constituents in parts per million)					
	Adjacent wells					
	Deep	Shallow	Deep	Shallow	Deep	Shallow
	6–R–1	7–R–1	7–U–2	8–U–18	9–U–1	9–U–45
$K \times 10^5$ at 25° c. of c.			122		125	
Boron		2 94	0 64	5.06	0 53	2 33
Bicarbonate HCO_3, Carbonate CO_3	331	740	232	220	241	382
Chloride Cl	51	1,542	35	867	39	365
Sulphate SO_4		4,444	414	1,890	405	2,280
Calcium Ca		680	127	256	120	352
Magnesium Mg		616	36	344	44	187
Alkali bases as Sodium Na		1,468	95	610	88	716

Analyses were made of samples collected from deep wells located in the lower part of the Oxnard Plain in what is regarded as the "pressure area," i.e., the area in which the deeper water is under such hydrostatic pressure as to rise in the wells nearly to or above the ground surface. This area lies between the coast and the main highway between Ventura and Camarillo. In this area 55 wells have been sampled for analyses. The water samples from 45 of these wells are remarkably uniform in quality, having conductances ranging from 100 to 160; boron from 0.3 to 0.6 p.p.m.; per cent sodium from 30 to 40; chlorides from 50 to 65 p.p.m.; and sulphates from 300 to 600 p.p.m.

In view of the fact that the irrigation wells located in the "pressure area" of the Oxnard Plain draw water from gravel strata that lie well below present sea level, it might be suspected that contamination by sea water would occur in some of them. Of the 55 wells within this area that have been sampled, 18 are located within one mile of the beach. Only two of these, 9–W–2 and 11–X–1, show definite evidence of sea water contamination. Five others, although located within a few hundred feet of the beach, appear to be as free from such contamination as any of the wells within the area. One other well within the one-mile zone, 10–W–8, is slightly saline but the evidence of sea water contamination is not convincing. There are seven wells located near the foothills in quadrangles 12–W, 13–U and 13–V that are definitely more saline than those farther out in the plain or nearer the beach.

Montalvo Basin

The Montalvo Basin includes the upper part of the delta of the Santa Clara River between Saticoy and the State highway. It is recognized as a "nonpressure area" because the hydrostatic pressure on its underground waters is not great enough to lift these waters through the wells to the ground surface. Within this area 21 wells have been sampled and analyzed, some of them repeatedly. The results of these analyses indicate that the quality of the underground water in the Montalvo Basin is substantially the same as that in the deeper gravels of the Oxnard Plain in the "pressure area." The inference is that there is direct water connection through the Montalvo Basin from the underflow of the Santa Clara River to the gravel strata in the sediments of the Oxnard Plain.

In general the water found in the 21 wells sampled in this basin would be classed as of intermediate salinity, with the boron content ranging around 0.5 p.p.m. Three of the wells, 8–R–6, 8–S–6, and 10–R–11, have rather high sulphate contents, but in view of the low sodium percentage these concentrations should not cause serious concern.

Santa Paula Basin

The Santa Paula Basin includes that section of the river valley below Santa Paula Creek extending to the Montalvo Basin. The arable land in this section is devoted largely to citrus and walnuts and is highly developed. It is irrigated mostly with local underground waters. These waters as sampled from 61 wells show rather more diversity in quality than is found in the wells of the Oxnard Plain. Four of them are located in the canyons north of the main valley. One of these four, 10–O–1, is a shallow well in Wheeler Canyon with high salinity and high boron. Two others, 10–P–1 and 2, are located on the west side of Aliso Canyon. Both are of intermediate salinity, one with low boron and the other with an intermediate boron content, 0.87 p.p.m. The fourth of these foothill wells, No. 11–O–1, is of low salinity with boron not reported.

The three wells adjacent to Telegraph Road west of Wells Road have concentrations similar to those of the better wells in the Montalvo Basin. The two wells adjacent to Wells Road south of Telegraph Road, 10–Q–9–9 and 10–R–6, are rather more saline, as are also the two wells near the intersection of Olive Road with Telegraph Road, 10–Q–3 and 6, and the two near the intersection of Cummings Road and Middle Road, 11–P–2 and 9. Another saline well is found at 11–P–13 south of Middle Road and east of Briggs Road, and still another near the lower end of the area, 10–R–22.

With these exceptions the underground waters of this basin tend to range lower in salinity than those of the Montalvo Basin. This is particularly true of a number of wells located on the upper part of the delta of Santa Paula Creek in quadrangles 12–O and 13–O. The wells of this group are not only low in salinity but in boron also. The wells located in the vicinity of Santa Paula show the beneficial effects of the fresher water contributed from Santa Paula Creek as compared with that occurring in the gravels of the main river channel. In general also the deeper wells appear to yield somewhat better water.

Fillmore Basin

The wells in this basin are located on both sides of the Santa Clara River from the junction of Sespe down to Santa Paula Creek. There are 54 of these wells for which the analyses were made. This basin includes the delta of Sespe Creek and in consequence some of the wells near that delta in quadrangles 16–N and 16–O have boron concentrations ranging up to 1.00 p.p.m. or higher. On the other hand, there are a number of wells contiguous to and north of the main highway west of Hall Road that have the lowest concentrations of salinity and of boron found in the whole valley. Wells in this section of the basin between the railroad and the river are slightly more saline and contain somewhat more boron.

Wells at 14–O–16 and at 15–N–5 are somewhat anomalous in that they have much higher concentrations of sulphate than neighboring wells, while the well at 16–M–2, in which the salinity is low, has an abnormally high boron content.

In general the wells of this basin south of the river in the vicinity of Bardsdale have higher salinity than those north of the river, and some of them also have relatively high boron contents. It seems probable that the boron contamination occurs through strata of gravel connecting under the river with Sespe Creek.

Piru Basin

The Piru Basin includes the section of the Santa Clara River Valley above the delta of Sespe Creek. Within that basin 25 wells have been sampled. In general the wells of this basin are located not far from the river channel because the valley is narrow in this section. The waters are, for the most part, more saline than those of the Fillmore Basin, particularly are they higher in sulphates. The boron content ranges rather high also, only one well having a boron content as low as 0.35 p.p.m. and range up nearly to 1.5 p.p.m. The higher sulphate concentrations occur at locations 18–N–13, 19–N–1, 19–N–18 and 20–N–11.

These higher concentrations of boron and sulphate doubtless reflect the influence of Piru Creek waters, which are notably high in these constituents. There may be some local sources of sulphate contamination in the buried sediments, but it seems probable that Piru Creek is the chief source.

REVIEW OF THE SANTA CLARA RIVER VALLEY

Underground Waters

By way of review of the observations noted in the preceding paragraphs it may be pointed out that in the underground waters of the Santa Clara Valley there is not a progressive increase in salinity in the downstream direction. The wells in the Piru Basin yield waters that are, if anything, slightly more saline and in general rather higher in boron than the wells of the Montalvo Basin and the Oxnard Plain. This is a condition not usually found along streams that are extensively used for irrigation. The usual condition is that salinity increases in the downstream direction because the return flow from irrigated lands is more concentrated than the water applied as irrigation.

In the case of the Santa Clara River most of the sulphate salinity and much of the boron is contributed from Piru Creek, while Sespe Creek contributes chiefly boron and chloride. The flood waters of both streams are much less saline than the low-water flow, and it is these flood waters that largely replenish the underground supplies in the lower basins. The contributions of Santa Paula Creek and of several of the smaller streams are also much less saline and lower in boron content than those of Sespe and Piru Creeks; consequently, the local underground waters replenished from the former streams are of much better quality than those replenished from the low-water flow of the latter.

It should be kept in mind also that in respect both to salinity and boron concentration the water supply of the Santa Clara Valley is now, taken as a whole, close to the limit of tolerance for the more sensitive crops. In some sections of the valley crop injury from these causes has occurred, and in order to diminish these injuries it has been necessary to reject some local water supplies and find others. The productive capacity of much of the irrigated land is very high, and it is now largely used for crops that yield high returns. These facts emphasize the importance of giving serious consideration to the whole subject of the quality of the available supplies of irrigation water and to the effect of the various possible methods of increasing this supply by storage and conservation measures on the quality of the water in the several basins of the valley.

In view of the generally high concentrations of salinity and boron in these waters it is manifestly essential to make provision, in any plan for more complete water utilization, for disposing into the ocean each year of a sufficient quantity of drainage water to carry away from the irrigated lands approximately as much of the highly soluble salinity and boron as is annually contributed by the incoming irrigation water. It would be highly inadvisable to undertake a program of water conservation that does not include a provision for drainage adequate to remove these soluble salts.

CALLEGUAS CREEK BASIN

The drainage area of Calleguas Creek lies south of the Santa Clara River area from which it is separated by a sharp divide known as South Mountain. The topography of the area is broken by numerous low hills, and it yields very little surface water. It seems probable also that the various basins are not freely connected to the main stream. There are, probably, underground barriers that impede the movement of underground water from the higher to the lower basins.

Epworth Basin

Epworth Basin lies on the south slope of South Mountain above the town of Moorpark. Water samples have been analyzed from four wells in this basin. The analyses indicate that the underground water in this basin is remarkably pure. The highest conductance reported is 24.5, the highest boron is 0.08 p.p.m. One of the samples has a high percentage of sodium, 66, but the others are low. The highest chloride is 21 p.p.m., and the highest sulphate is 33 p.p.m.

West Las Posas Basin

This is a small detached basin lying between South Mountain and Camarillo Hills. Water samples have been analyzed from five wells. In general the salinity is higher in these waters than in those of Epworth Basin, but they are all well below the limit of tolerance for irrigation use, except possibly the well located at 12–S–3 for which a sodium percentage of 60 is reported.

Simi Valley

The Simi Basin collects the drainage of the headwaters of Calleguas Creek, of which Tapo Creek is the largest tributary. In this basin 23 wells have been sampled. These analyses show that there is marked diversity in the quality of the waters within the basin and indicate that they are not freely interconnected. In general the wells located south of Simi yield water of low salinity, while those north of the highway and particularly those adjacent to Tapo Creek have high salinity. Three wells located near the southeast corner of the basin are unusual for this general area in having higher concentrations of chloride than of sulphate. One of these, however, has very low total salinity.

Several of the wells of this basin yield water having concentrations of boron that are within or above the limits of tolerance for the more sensitive crops. These wells are: 20–R–2 and 20, 21–R–11, 22–R–3, 6, 9, 19 and 21. The fact that these boron concentrations are high enough to be injurious is shown by the impaired growth conditions and yields in some of the walnut groves of the basin.

Las Posas Valley

This basin includes the central portion of Calleguas Creek Valley from Moorpark to Somis. Here also 23 wells have been sampled. In respect to total salinity three of these wells may be classed as low, viz: 16–R–3 and 6, and 17–R–15. Five others may be classed as rather too saline for safe irrigation use, viz: 16–R–7, 17–R–14, 18–Q–1, 18–R–2 and 18–R–12. In these five the sulphate concentration ranges above 1200 p.p.m. In the remaining 15 wells the salinity concentrations are intermediate.

In respect to boron the conditions are somewhat less favorable. For 14 of the 21 wells in the basin for which boron is reported the concentrations range above 0.50 p.p.m. In three of these the boron exceeds 1.0 p.p.m. In this basin as in the Simi Basin there is evidence of boron injury in some of the walnut groves.

Pleasant Valley

This basin, which includes the town of Camarillo, is topographically a part of the Oxnard Plain, similar in position to the Montalvo Basin which lies west of it. Water samples from 19 wells have been analyzed. Of these 19 wells at least eight may be classed as of low salinity, and only one as of high salinity. The remaining ten while classed as intermediate in respect to salinity tend to range toward the low side of that group. The boron conditions are also favorable. Only one well exceeds 1.0 p.p.m. and only two others are clearly above 0.50 p.p.m.

These analytical results appear to support the view that the underground waters of Pleasant Valley Basin are not replenished from the upper basins except by surface run-off. The water found here is definitely less saline than is much of that found in the three upper basins along the main drainage channel.

Santa Rosa Valley

This basin is a small one lying east of Pleasant Valley Basin. Its underground waters are replenished by drainage from upper Conejo Creek and Santa Rosa Creek. Conejo Creek after leaving the valley joins Calleguas Creek south of Camarillo. Water samples have been obtained from 15 wells in Santa Rosa Basin. In this basin as in the Epworth Basin the underground water is of low salinity. Only one well would be classed as intermediate with 409 p.p.m. of sulphate. Boron is reported for only five wells but its concentration is less than 0.2 p.p.m.

REVIEW OF THE CALLEGUAS CREEK AREA

This drainage area is unlike that of the Santa Clara River in that the several basins are well defined topographically and their underground waters appear to be very slightly interconnected. The three basins that are contiguous to the stream channel above the coastal plain all contain waters having such differences of salinity and boron content as to suggest that they are not interconnected even within each basin. There are some waters of high salinity and high boron content in each of these three basins. In the three noncontiguous upper basins the underground waters are generally of low salinity and low boron content, while in the lowest basin adjoining the coastal plain the underground water is generally of lower salinity and boron content than is found either in the three upstream basins or under the Oxnard Plain.

CHAPTER VIII

WATER SUPPLY OF SANTA CLARA RIVER VALLEY

Santa Clara River drains an area of 1600 square miles. Santa Clara River Valley from the county line on the east to its debouchure onto the Coastal Plain has been divided into three basins for convenience of study. These are called in order downstream Piru, Fillmore and Santa Paula Basins and reference is made to Plate I for their location and area. The characteristics of each differ somewhat from those of all others and each was studied separately as to sufficiency of water supply. It was found, however, that for the 40-year period beginning with fall 1892 for which estimates of stream discharge were made that no shortage would exist at any time in any of the separate basins either for the present irrigated acreage or for any conceivable ultimate irrigated acreage. For this reason and for the additional reason that there are no visible barriers between the three, the three basins are here discussed as one.

In this area there are in round figures 45,000 acres classed as valley land, i.e., lying between the toes of the foothills on either side. In some places the toe of the foothills is a definite line and in others a matter of judgment. Of this, 8600 acres are in roads, river wash, barrancas, etc., and can never be irrigated under any condition which can be conceived, and 23,500 net acres are irrigated or are using water for domestic purposes, leaving 13,000 acres gross which from a topographic standpoint may be regarded as more or less feasible for irrigation. In the foothills both to the north and south of the valley are 9000 acres classed as "irrigable or habitable" on Plate XLVII in rear pocket, and of this, 800 net acres are now irrigated.

Most of the better lands in the valley which are accessible to water at reasonable cost are now under irrigation. While some first class lands remain uncultivated most of the remainder of the valley lands are, in some areas, of poor quality, in others expensive to prepare because of rocky soil or rough topography, and in still others at such elevation that the cost of water will be excessive. All three of these adverse conditions are present in some of the valley land. The development of the lower lying lands classed as irrigable has been deterred because they are sandy and infertile. Cost of water limits the crop to citrus and avocados for lands lying at higher elevations in the valley. At the best, progress in irrigating these areas should be slow and should depend to a large extent on what lies in the future for citriculture.

It has been desired to be conservative in estimates of surplus water, however, and for that reason as large an estimate of ultimate development as it was possible to conceive has been made. Ultimate development has been based on the irrigation of 75 per cent of the area on the valley floor not now irrigated and not in river wash, etc. On

this basis, 10,000 acres additional in the valley will ultimately require water.

Irrigation of lands in the foothills designated as "irrigable or habitable" would encounter even more difficulties than irrigation of the valley lands. The cost of water would be greater because of the higher lift, the soil on the average is less fertile and farming operations would be more expensive because of topography. A favorable feature is that these lands, if planted in citrus, would require less frost protection than valley lands. It is to be doubted that a large percentage can be placed on a permanently profitable basis, but it is probable that more will be irrigated than can be irrigated profitably. Here, as with the higher lands in the valley, the only possible irrigated crops are citrus and avocados. For the same reason as for the valley the additional land which may be irrigated in the foothills is estimated at a generous figure and is taken at 25 per cent of that now unirrigated. On this basis, the total additional land to be irrigated in the hills is 2000 net acres.

The combined additional land in both valley and hills which may possibly use water and on which ultimate water supply calculations are based is, therefore, estimated at 12,000 acres.*

Water Supply

When the water table under the valley is high, rising water covers a greater length of the stream channel and there is less opportunity for percolation of floods. Consequently the recharge of the underground basin would be less under such conditions than with the same stream discharge occurring when water table was low. An estimate of the supply reaching each underground basin was made month by month for the 40-year period ending fall 1932. It was assumed that the area irrigated was the same as in 1932. In order to estimate the variable percolation with different elevations the position of the water table in each basin each month was calculated from the difference in input and output and the void space filled or drained. Table 20 summarizes the results for the valley.

The 40-year period embraces one wet and two dry cycles, consequently the recharge would be less than average although giving a surplus. Because of the drift downstream the basins would have been somewhat depleted at the close of the period as the close was in a dry cycle. The estimated outflow supplied by this depletion averages 1500 acre-feet per year which added to the 26,400 acre-feet surplus gives a total of 27,900 acre-feet which would be disposed of as follows:

	Acre-feet
Exportation to lands below for irrigation	700
Underground outflow	5,000
Rising water	22,200
Total	27,900

The 27,900 acre-feet is the amount of water which having reached the water table is not used, and discharges uniformly out of the lower limit of Santa Clara Valley. Most of the rising water percolates into the river wash above Montalvo Bridge and together with the underflow replenishes underground supply of Oxnard Plain.

* Compare with table on page 220.

TABLE 20

PRESENT AVERAGE ANNUAL SUPPLY, DEMAND AND WASTE

Underground basins—Santa Clara Valley from County Line West—Spring 1892 to Fall 1932

		Acre-feet	
Supply—County Line to Saticoy			
Percolation from all streams during floods		55,000	
Percolation from rain on valley floor		14,300	
			69,300
Consumption*			
Beneficial—			
Agriculture:			
**Camulos area,	894 acres at 1.67	1,490	
**Piru Basin,	3,208 acres at 1.33	4,250	
Bardsdale area,	1,776 acres at 1.50	2,670	
Fillmore Basin,	6,867 acres at 1.33	9,150	
Santa Paula Basin,	10,756 acres at 1.15	12,350	
Domestic,	1,103 acres at 1.20	1,320	
		32,200	
Nonbeneficial—			
***Willows along river,	2,630 acres at 3.33	8,760	
	1,040 acres at 2.84	2,950	
		11,700	
			42,900
Surplus			26,400

*The values given are consumptive use, not diversion or pumpage. As the climate grows more arid and the summer temperatures are greater with distance east, water consumed by irrigated crops in the summer is greater. The values used are based on experimental work in southern California by University of California and by Division of Agricultural Engineering, U. S. Department of Agriculture in cooperation with Division of Water Resources.

**Camulos area is partly in Piru Basin and partly in the eastern basin. Bardsdale area is all in Fillmore Basin but uses water from Piru Basin. As both areas use excessive quantities of water, consumptive use is believed larger than with ordinary use.

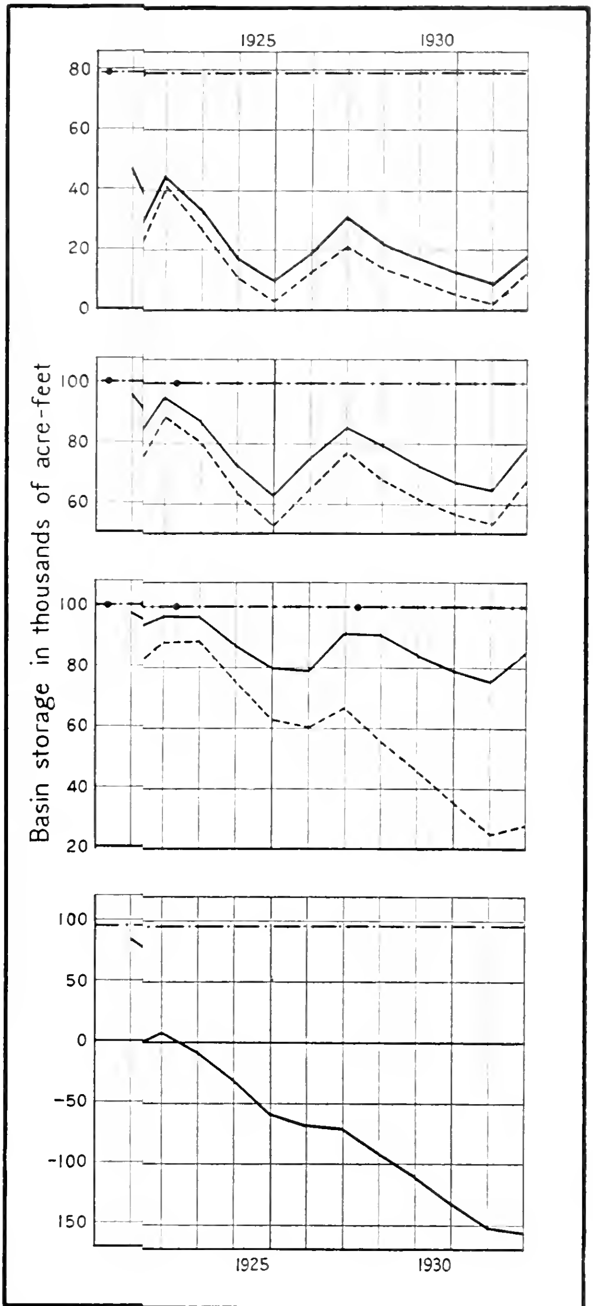
***The values used are estimated consumptive use from water which has penetrated to the water plane, suggested by the above Federal Bureau and based on similar cooperative investigation. The larger value is for willows in rising water areas where the entire consumptive use is from such water. The smaller value is for willows growing on land somewhat above the water plane where the winter use is provided by rainfall and only the summer use is from ground water.

In addition to the above water, the average annual flood discharge past the lower end of Santa Paula Basin for the period is estimated at 150,000 acre-feet, part of which also percolates in the river wash and enters the Oxnard Plain supply.

The effect of additional development of irrigation in Santa Clara Valley will be to lower the water table further and allow greater opportunity for percolation of floods. An additional 12,000 acres in the valley and on the hills may conceivably use water in the future. Eleven hundred acres of this is now in willows, consuming during the growing season an estimated 3200 acre-feet. The net increase for ultimate development is estimated at 11,000 acre-feet but additional use would undoubtedly be made up in part by increased percolation of floods made possible by the lowered water table. No attempt has been made to approximate this for the 40-year period. The net result would be a decrease in the 178,000 acre-feet passing out of Santa Clara Valley with probably the major portion of the decrease borne by floods on the average.

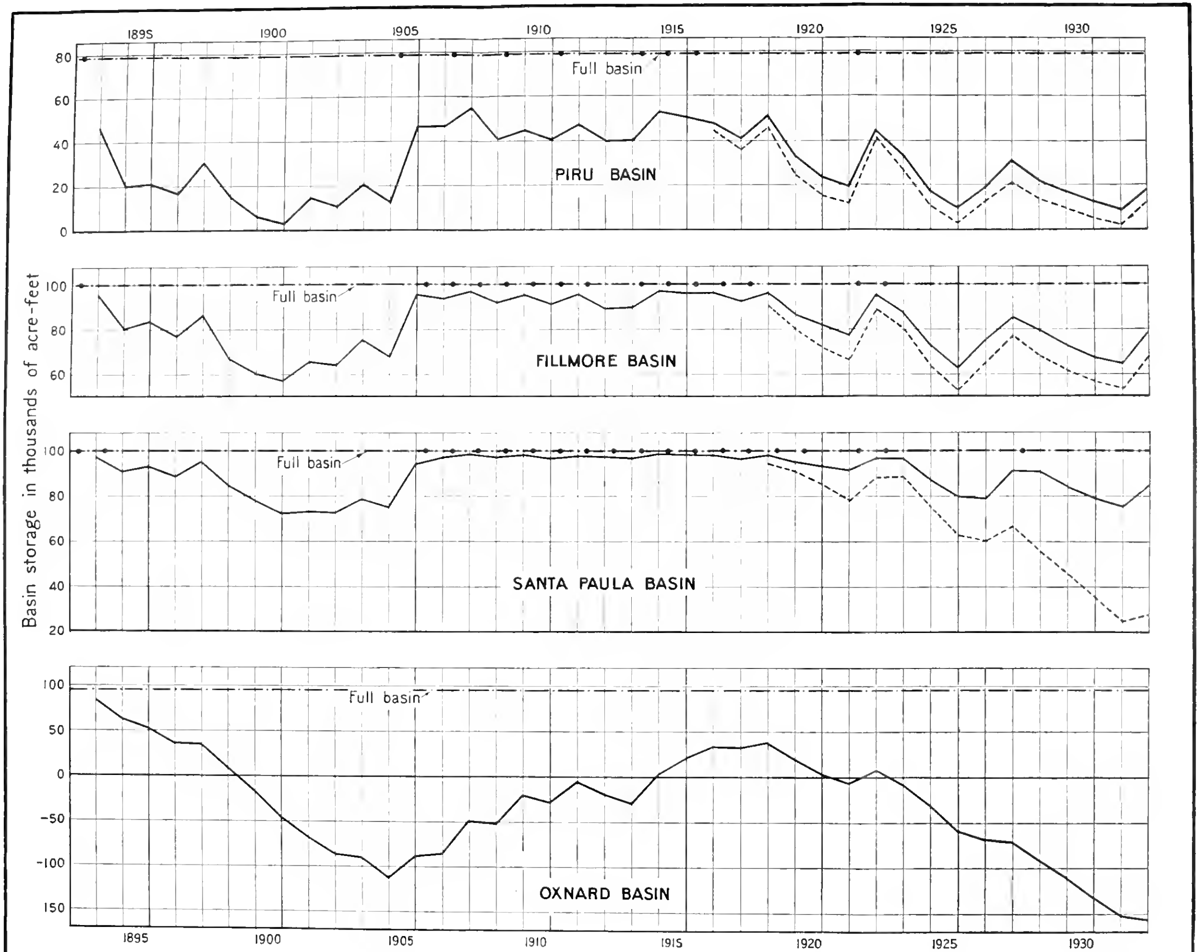
A striking feature of the draft on underground water in the valley is the wasteful consumption by willows which cover almost 3700 acres along the river. Their toll is almost 40 per cent of the present estimated beneficial consumption and over 80 per cent of the estimated additional consumption which might occur. It is undoubtedly possible to lower the water table and destroy the growth in part at least, thereby releasing controlled water for beneficial use.

On Plate XXIV are graphs giving the estimated water in storage in Piru, Fillmore and Santa Paula Basins and Oxnard Plain for the



ON

e highest in the spring and in some years the lines marked "Full Basin." The draft on which covered one wet and four dry y fill during 1915 to 1920. In other words



VARIATION IN STORAGE WITHOUT CONSERVATION
SANTA CLARA RIVER BASINS

——— Present use, fall storage ----- Ultimate use, fall storage

• Years in which basin is full in spring

The graphs give the reservoir content in the fall when it is at the lowest for the year. It is at the highest in the spring and in some years Piru, Fillmore and Santa Paula Basins would be full in the spring. These years are shown by dots on the lines marked "Full Basin." The draft on each basin and consequent changes in water content is based on that found during the investigation which covered one wet and four dry years. The draft would probably be less in wet than in dry years and if so Oxnard Basin might fill during 1915 to 1920. In other words, the calculated long time shortage may not actually exist.

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fall lows of each year of the 40-year period under discussion and with the assumption that the area irrigated in 1932 was irrigated during the entire period.* The levels at which the reservoir was considered full and empty are somewhat arbitrary. The full condition is that at which the underground water will be lost to the basin in a short period after the flood season and the empty condition the level at which pumping lift would not be unreasonable or in the case of Oxnard Plain the level at which a gradient toward the ocean would be sustained. There is, however, capacity below this level which could be tapped in emergency. These graphs indicate that all basins in Santa Clara Valley would fill in wet cycles with present irrigation draft and they show the recession in storage or water table caused by the dry cycles, one of which exists at present. In the 40-year period there was another dry cycle of approximately similar severity. As indicated by these graphs, all basins in the valley would have filled in spring 1922 and therefore the ten and one-half year period from then to fall 1932 has been selected for intensive study, as more reliable data are available than for the previous dry cycle, and as condition of water supply approximately as adverse as in that cycle occurs in the latter period.

Although not shown on the graph it is estimated that the surplus of the wet cycle 1905–1918 was sufficient to fill the basins and together with subsequent wet years to 1922 cause the waste of 500,000 acre-feet into the ocean.

The following table is based on the same draft as Table 20, but the water supply is that for the shorter deficient period:

TABLE 21

PRESENT AVERAGE ANNUAL SUPPLY, DEMAND AND WASTE

Underground basins—Santa Clara Valley west of County Line—Spring 1922 to Fall 1932

	Acre-feet	
Supply—County Line to Saticoy—		
Percolation from all streams	50,900	
Percolation from rain on valley floor	8,500	
		59,400
***Demand**—County Line to Saticoy—		
Beneficial	31,200	
Nonbeneficial	11,700	
		42,900
Surplus		15,500

*For details, see preceding table.

Although there would have been surplus recharge of the basins, it would have been less than the average and the water table would recede during the period because of the drift of the water downstream underground. The average annual depletion is estimated at 5300 acre-feet, giving with the surplus, 20,800 acre-feet annually which would be disposed of as follows:

	Acre-feet
Exportation to lands below for irrigation	700
Underground outflow	5,000
Rising water at lower end of valley	15,100
Total	20,800

* It should be noted that these graphs show the amount of water in storage in the fall of each year. In the spring the amount in storage would be greater. The dots on the lines marked "Full Basin" show the years in which the different basins would be full in the spring. Note that Oxnard Basin does not show the full condition at any time but it could very well be that the draft in wet years would be less than that found during the investigation, in which the years were dry, and that consequently the basin would fill.

fall lows of each year of the 40-year period under discussion and with the assumption that the area irrigated in 1932 was irrigated during the entire period.* The levels at which the reservoir was considered full and empty are somewhat arbitrary. The full condition is that at which the underground water will be lost to the basin in a short period after the flood season and the empty condition the level at which pumping lift would not be unreasonable or in the case of Oxnard Plain the level at which a gradient toward the ocean would be sustained. There is, however, capacity below this level which could be tapped in emergency. These graphs indicate that all basins in Santa Clara Valley would fill in wet cycles with present irrigation draft and they show the recession in storage or water table caused by the dry cycles, one of which exists at present. In the 40-year period there was another dry cycle of approximately similar severity. As indicated by these graphs, all basins in the valley would have filled in spring 1922 and therefore the ten and one-half year period from then to fall 1932 has been selected for intensive study, as more reliable data are available than for the previous dry cycle, and as condition of water supply approximately as adverse as in that cycle occurs in the latter period.

Although not shown on the graph it is estimated that the surplus of the wet cycle 1905–1918 was sufficient to fill the basins and together with subsequent wet years to 1922 cause the waste of 500,000 acre-feet into the ocean.

The following table is based on the same draft as Table 20, but the water supply is that for the shorter deficient period:

TABLE 21

PRESENT AVERAGE ANNUAL SUPPLY, DEMAND AND WASTE

Underground basins—Santa Clara Valley west of County Line—Spring 1922 to Fall 1932

	Acre-feet	
Supply—County Line to Saticoy—		
Percolation from all streams	50,900	
Percolation from rain on valley floor	8,500	
		59,400
***Demand**—County Line to Saticoy—		
Beneficial	31,200	
Nonbeneficial	11,700	
		42,900
Surplus		15,500

*For details, see preceding table.

Although there would have been surplus recharge of the basins, it would have been less than the average and the water table would recede during the period because of the drift of the water downstream underground. The average annual depletion is estimated at 5300 acre-feet, giving with the surplus, 20,800 acre-feet annually which would be disposed of as follows:

	Acre-feet
Exportation to lands below for irrigation	700
Underground outflow	5,000
Rising water at lower end of valley	15,100
Total	20,800

* It should be noted that these graphs show the amount of water in storage in the fall of each year. In the spring the amount in storage would be greater. The dots on the lines marked "Full Basin" show the years in which the different basins would be full in the spring. Note that Oxnard Basin does not show the full condition at any time but it could very well be that the draft in wet years would be less than that found during the investigation, in which the years were dry, and that consequently the basin would fill.

In addition to this, the flood discharge past the lower end of the Santa Paula basin is estimated to have averaged 52,000 acre-feet annually for the period.

The estimated surplus even for the deficient period is greater than the assumed additional draft of 11,000 acre-feet which may eventually develop. The result of such future development, without conservation, would obviously be, for a similar dry cycle, a greater lowering of the water table during the periods of drought and a decrease in rising water at the lower end of the valley but not a shortage in supply to the underground water.

On Plate XXIV is shown the estimated change in underground reservoir storage in the shorter period for each of the basins in the Santa Clara Valley for ultimate development and if no conservation is attempted. The waste out of the valley (not into ocean) is estimated to average 68,000 acre-feet annually for this period and for ultimate possible development. Of this waste, 18,000 acre-feet would be controlled water, i.e., rising water and underflow, while the flood waste is estimated to average 50,000 acre-feet. Computations indicate that during the dry period in addition to present percolation an average of 2000 acre-feet per annum of flood water which wastes with present conditions would percolate because of lower water table. In the wet period under such conditions a much larger amount of flood waste would percolate before the basins filled than under present conditions because at present they are less empty than would be the case if draft were greater.

Conclusion

In the foregoing are set out briefly the results of elaborate studies on the hydrology and irrigation demands of Santa Clara Valley in Ventura County. These results are stated numerically, which tends to give too great an appearance of definiteness but no other method of statement is feasible. Many assumptions have been made as the basis for the calculations which resulted in the conclusions but each assumption has been as to a detail on which experimental work or established engineering method has produced a satisfactory basis for assumption. Errors in assumption tend to balance one another and while it is not intended to convey that the calculations have resulted in correct evaluations of surplus yet it is believed that the margin is so large that a general conclusion can be safely made as follows:

The natural supply to each of the underground basins of Santa Clara Valley during a period similar to the forty-year period beginning fall 1892 is more than sufficient not only for present irrigation draft but for any conceivable ultimate draft. Lowering of the water table such as has occurred in the past several years is a natural result of a smaller water supply due to subnormal rains. Precipitation tends to move in cycles and although the water table will lower even more as development proceeds, the basins will fill in wet cycles and the water table rise in normal years. The greatest fluctuation occurs in Piru Basin and this underground basin gives the principal opportunity for conservation as shown by the depth to water table on Plate XXXVI. Conservation will tend to maintain the water table in dry cycles but will result in greater flood waste in wet cycles, because the basins will be less empty than they otherwise would be and will, therefore, fill more rapidly thereby cutting off percolation opportunity.

CHAPTER IX

WATER SUPPLY OF CALLEGUAS CREEK BASIN

The irrigated portions of Calleguas Creek consist of several more or less sharply isolated valleys, as will be noted from Plate I. The mountainous portion of the basin consists of absorptive rocks to a large extent (Plate LII in rear pocket) and this, together with the absorption of occasional floods by the stream beds in their course across the valley fill, results in almost negligible discharge into the ocean. The total run-off tributary to the valley has not been estimated nor can a reliable estimate of the usable water supply in any of the valleys of the basin be made with present data. No evaluation of the supply as compared to the demand has been made. Such conclusions as are reached are regarded as indefinite and are based on the change in water table during the periods of record. Geology and quality of water of each of the following valleys are discussed in Chapters III and VII, respectively.

SIMI VALLEY

The boundary line between the valley floor and mountain toe is not definite in a considerable length of the periphery of the valley, but using a somewhat arbitrarily selected boundary for those portions gives 12,400 acres as the total area of valley floor. The area of hills around the margin of the valley which are designated "irrigable or habitable" on Plate XLVIII, in rear pocket of report, is 4600 acres. Approximately 7000 net acres of valley floor are now using water, 700 acres are in roads, barrancas, etc., which are nonirrigable and 4700 acres may be regarded as irrigable from a topographic standpoint. On the hills 250 acres are now irrigated. It is assumed that 75 per cent of the remaining irrigable valley lands or 3600 acres and 25 per cent of the remaining hill lands or 1200 acres might use water if it were available at a reasonable cost.*

Water Supply

This is derived in small part from percolation of rainfall on the valley floor to the underlying water table. The 40-year average rainfall on the valley floor is estimated at 14.4 inches and for the 11 years beginning fall 1921 at 13.0 inches. The estimated annual deep percolation of rainfall for the 40-year period is about 2000 acre-feet. Another minor source of supply is percolation from streams entering the basin but these are small and flow only at intervals. The outflow of the valley is small except in occasional years of heavy precipitation. It may not average more than 700 acre-feet per year. If so most of the rainfall on the watershed and valley floor is retained.

The total watershed above the valley floor is 39,600 acres or 62 square miles. A possible major source of supply is the rainfall on the

* Compare with table on page 220.

basaltic rocks of the southern watershed. These are the result of extrusion, are porous and should allow considerable deep percolation which should be tributary to the valley. The average annual rainfall in this portion of the watershed is 15 inches. The remainder of the watershed is of tight material except for the Saugus formation to the north. This is cut off from the valley by an impervious formation and there appears to be no possibility of an underground supply from this source, leaving the basalts as the only portion of the watershed from which such a supply could come. No reliable evaluation of the supply from this source is possible and since this may be so large an item in the total no attempt is made to evaluate the total supply.

Use of Water

The duty of water is about 1.33 acre-feet per acre for citrus groves and deciduous orchards, and about 2.25 acre-feet for truck, garden and alfalfa. The estimated consumption of irrigation water for the 6400 acres now irrigated is 7700 acre-feet per annum.

Surplus or Shortage

During the period of investigation water levels dropped each year over the entire valley except from fall 1931 to fall 1932. During the first four years the rainfall was subnormal and in winter 1931–32 was about 17 per cent above normal. In the period between fall 1931 and fall 1932, the water level in wells south of Cochran Street rose in general and in wells north of that street fell. Near the creek to the east of Tapo Canyon, levels rose for a half mile further north than Cochran Road, but in the vicinity of Stow Road levels dropped for a half mile further south than Cochran Road.

The wells from the settlement of Simi to the western end of the valley rose but in this area the material is all tight and while the water levels are not under pressure in the same way as when an aquifer is confined by a stratum of impervious material, yet fluctuations are not indicative of change of storage. This same condition exists to an extent over the entire valley.

Conclusion

It is not certain that recharge from deep percolation in the mountains to the south during the winter had reached the valley by fall 1932 and it may be that deep percolation from rainfall in the northern part of the valley had not reached the water table by that time. While nothing very definite is indicated by present information, yet it may be possible that the southern part of the valley has a sufficient supply over the long-time average of the forty years beginning 1892 for the present draft and the northern an insufficient supply. No estimate can be made as to whether additional draft on the southern part can be sustained.

LAS POSAS VALLEY (MOORPARK-SOMIS AREA)

As in the other valleys of Calleguas Creek Basin, the boundary between hills and valley floor is not definite along the entire periphery of the valley. Below the line chosen the area of valley floor is 12,000

acres. The area of hills around the margin of the valley designated as "irrigable or habitable" on Plate XLVIII, in rear pocket of report, is 24,800 acres. Approximately 6300 acres of valley floor are now using water, 1300 acres are in roads, barrancas, etc., which are not irrigable and 4500 acres may be regarded as irrigable from a topographic standpoint. On the hills 690 acres are now irrigated. It is assumed that 75 per cent of the remaining irrigable valley lands or 3400 acres and 25 per cent of the remaining hill lands or 6200 acres might some day use water if it were available at reasonable cost.*

Water Supply

This is derived in small part from percolation of rainfall on the valley floor to the underlying water table. The average rainfall for the 40-year period beginning fall 1892 is estimated at 13.9 inches and for the eleven years beginning fall 1921 at 12.5 inches. The estimated annual deep percolation for the 40-year period is about 1600 acre-feet. Percolation from streams entering the valley is a minor source of replenishment to the underground basin. These streams are small and flow only occasionally. Surface outflow from the valley is small except in occasional years of heavy precipitation. A portion of this comes from Simi Basin above and that originating in Las Posas Basin may not average more than 500 acre-feet per year.

The total watershed area above the valley floor is 40,400 acres or about 63 square miles. Practically the entire area is the Saugus formation with overlying areas of terrace gravel on the northern shed. The Saugus formation extends across the valley beneath the late alluvials of the valley floor. Both terrace gravel and Saugus formation are porous and absorb the rainfall upon them, and the formation allows the water thus absorbed to be conducted beneath the valley floor where it is within reach of pumps. The average rainfall on the watershed is slightly more than 15 inches. No reliable evaluation of the supply to the valley from this source is possible but it is believed to be large. No attempt is made to evaluate the total water supply.

Use of Water

The duty of water is about 1.33 acre-feet per acre for citrus groves, about 1.86 acre-feet for deciduous trees and about 1.30 acre-feet for beans. The estimated consumption of irrigation water for the 6300 acres now irrigated is about 8400 acre-feet. In addition, about 3600 acre-feet are exported to West Las Posas Valley and about 700 acre-feet to Pleasant Valley.

Surplus or Shortage

During the period of investigation water levels dropped somewhat over the entire valley except from fall 1931 to fall 1932. During the first four years precipitation was subnormal and in winter 1931–32 was about 20 per cent above normal. In the period between fall 1931 and fall 1932 the general water level neither fell nor rose.

Conclusion

It is probable that recharge from deep percolation in the mountains during the winter had not made itself felt entirely by the fall of 1932

* Compare with table on page 220.

since the time of travel should be long. Nothing very definite is indicated but it is believed that water supply over the long-time average is sufficient for present acreage and exportation but conclusion can not be made as to whether supplies are sufficient for much additional draft.

WEST LAS POSAS VALLEY

This basin is bounded on the south by Camarillo Hills, on the north by South Mountain, on the east by the low topographic divide between it and Las Posas Valley, and on the west it merges into the Oxnard Plain, but the dividing line is marked by a slope somewhat more steep than the terrain either to the east or west. As is general in Calleguas Creek Basin, the boundary between hills and valley is not definite. This valley does not drain into Calleguas Creek, but is discussed under that general heading for convenience. Its surface waters debouch onto the Oxnard Plain and are dissipated before arriving at any major drainage channel. The water table slopes from Las Posas Valley entirely through West Las Posas Valley toward Oxnard Plain. There is no hydrographic divide between the two.

The total area of valley floor is 6200 acres. The area of hills around the margin of the valley designated "irrigable or habitable" on Plate XLVII, in rear pocket of report, is 3700 acres. Approximately 4200 net acres of valley floor are now using water, 300 acres are in roads, barrancas, etc., which are not irrigable and 1700 acres may be regarded as irrigable from a topographic standpoint. On the hills 110 acres are now irrigated. It is assumed that 75 per cent of the remaining valley irrigable lands or 1300 acres and 25 per cent of the remaining hill lands or 900 acres may some day use water if it were available at a reasonable price.*

Water Supply

Wells driven in this area give unsatisfactory yields and most of the water used is imported from Las Posas Valley and from Oxnard Plain. That from Las Posas Valley has averaged 3600 acre-feet for the past 10 years. The only source of local supply is deep percolation from rainfall on the valley floor and contribution from local watersheds, believed to approximate about 1200 acre-feet for the forty-year average rainfall of 14 inches. With present conditions this goes in large part to the underground supply of Oxnard Plain.

Conclusion

Water supply depends on supply of Las Posas Valley already discussed, and of the Oxnard Plain.

SANTA ROSA VALLEY

The area below the rather indefinite line between hills and valley floor is 8300 acres. The area of hills around the margin of the valley marked "irrigable or habitable" on Plate XLVII, in rear pocket, is 12,900 acres. Approximately 2550 net acres of valley floor are now using water, 180 acres are in roads, barrancas, etc., which are nonirrigable and 5500 acres may be regarded as irrigable from a topographic standpoint. On the hills 1020 acres are now irrigated. It is assumed

* Compare with table on page 220.

that 75 per cent of the remaining valley lands or 4100 acres and 25 per cent of the remaining hill lands or 3000 acres may use water at some future time if it becomes available at reasonable cost.*

Water Supply

This is derived in part from percolation of rainfall on the valley floor to the underlying water table. The forty-year average rainfall on the valley floor is estimated at 13 inches and for the eleven years beginning fall 1921 at 12 inches. The estimated annual deep percolation for the 40-year period probably does not exceed 1000 acre-feet. Percolation from the streams entering the basin is small in amount and it is thought that the outflow from the valley does not exceed 300 acre-feet on the average as it occurs only occasionally. If so, most of the rainfall on the watershed and valley floor is retained.

The total watershed area above the valley floor is 32,900 acres or about 50 square miles. The small watershed to the north is sufficiently porous to allow deep penetration of rainfall on it. That to the south is basaltic but it is not as porous as it is to the east above Simi Valley. The average rainfall on the watershed south of Santa Rosa Valley is about 14 inches and it is believed that the valley receives the major portion of its supply from rain on this area which has percolated into the fissures of the rocks and finally reaches the valley. No reliable evaluation of this or of the total water supply can be made.

Use of Water

No data on duty of water are available, but it may be assumed similar to Las Posas Valley. The important factor is water consumed rather than that applied and this is assumed the same as for Las Posas Valley. The estimated consumption of present crops is about 4200 acre-feet.

Surplus or Shortage

During the five years of the investigation there was little change in water levels at the wells measured although rainfall in the first four years was subnormal and in the last year above normal. This indicates a distant source of supply fed gradually to the valley.

Conclusion

No evaluation of water supply can be made, but from behavior of wells, it is calculated that it is sufficient for present draft. If the watershed to the south is fairly absorptive there may be water for additional acreage.

PLEASANT VALLEY

Pleasant Valley is an arm of the Oxnard Plain extending eastward. There is no boundary between it and the Oxnard Plain either on the surface or by definite underground structures. The boundary selected is believed to approximate the eastern limit of the wanderings of Santa Clara River as it built the Oxnard Plain. It does not appear possible that the river could ever have flowed further to the east. Well logs to

* Compare with table on page 220.

the west of the line shown as the boundary give much larger quantities of sand than do those to the east in which tight material predominates. The boundary is shown by a dotted line on Plate I.

To the east of the line of small dots on the plate, the underground waters are not under pressure and to the west they are. Pressure level in that portion to the west of the line is different from that of the Oxnard Plain. The Saugus formation underlies most of Pleasant Valley and many wells are drilled into it. Wells in Oxnard Plain do not penetrate this formation.

The total area of the valley floor is 22,000 acres. There are about 1500 acres of hills marked "irrigable or habitable" on Plate XLVII in rear pocket. Approximately 15,100 acres of valley floor are now using water, 600 acres are in roads, barrancas, etc., which are not irrigable and 6300 acres may be regarded as irrigable from a topographic standpoint. It is assumed that 50 per cent of the remaining valley lands or 3200 acres and 25 per cent of the remaining hill lands or 300 acres may use water at some future time if it is available at reasonable prices.*

Water Supply

This is derived in part from percolation of rainfall on the valley floor to the underlying water table. The forty-year average rainfall on the valley floor is about 13 inches and for the 11-year period beginning 1921 about 11 inches. The estimated deep percolation on the non-pressure area for the 40-year period probably does not exceed 2000 acre-feet per annum. Percolation from the streams entering the valley is small. About 700 acre-feet per annum are imported from Las Posas Valley.

Total watershed area above the valley floor is 1300 acres or about 21 square miles. Most of this is to the south and consists of intruded basalts. Hence, the watershed is less fissured here than further east. The estimated rainfall on the watershed is only 13 inches which would give no very large deep percolation later available to the valley even if the formation is open enough to allow it. The remaining small portion of the watershed is Saugus formation, but the supply to the valley from it must be insignificant. No reliable evaluation of total water supply can be made.

Use of Water

The estimated consumption of irrigation water for the area now irrigated is 16,500 acre-feet annually.

Surplus or Shortage

Water levels over the entire area dropped during the period of investigation but from fall 1931 to fall 1932 were stationary on the average. Precipitation was subnormal in the first four years, but in winter 1931–32 was 15 per cent above the estimated normal.

Conclusion

It is thought that the underground supply may be overdrawn but the extent of overdraft, if it exists, is not estimated.

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* Compare with table on page 220.

CHAPTER X

WATER SUPPLY OF COASTAL PLAIN

The term Coastal Plain as used in this report includes the city of Ventura, the Montalvo area and the Oxnard Plain. The city of Ventura is supplied by water from Ventura River and this matter is discussed in Chapter XIV under the heading of Ventura River. Most of the Oxnard Plain and the Montalvo area derive water supply naturally from Santa Clara River, and this is the principal source, but above the approximate line north of Santa Clara River labeled "Assumed Limit of Influence of Santa Clara River" on Plate I, the natural supply is from the north and is insufficient and in some places of poor quality. Therefore water is secured by pumping south of the line and conducting it to the area to the north, making this area also dependent on Santa Clara River. The location of the above line is governed by the two small mounds of terrace gravel which obtrude from the plain near Montalvo, the yield and location of wells and the contours of the water table. The contours indicate that the water to the north of the line must come from the north, while to the south of the line well logs and contours indicate water probably comes from the river.

The location of the eastern boundary of the Coastal Plain is also at what is believed to be the approximate limit of influence of the river as disclosed by well logs. In addition there is a rise in the ground surface which indicates the division between West Las Posas Basin and Montalvo area. Surface indications are entirely lacking at the boundary between Pleasant Valley and Oxnard Plain.

Eliminating the city of Ventura, the total area of Coastal Plain as thus delimited approximates 65,700 acres. Of this, 43,600 acres are now using water, and 8900 acres are in river wash, roads, etc., and will not use water in the future. From a topographic standpoint approximately 10,000 acres may be regarded as irrigable. The larger portion of this is in the extreme southern corner where Calleguas Creek discharges into the ocean and here the soil is sour and salty so that it will be difficult to reclaim. In addition to the land on the valley floor, 130 acres of tributary hill land are irrigated and approximately 1550 acres are classed as "irrigable or habitable." Most of this lies in the hills to the north.

As a basis for water supply calculations, it is assumed that about 5400 acres additional land will come under irrigation.*

Use of Water

Principal crops are beans, beets, alfalfa and truck. Citrus is gradually assuming greater importance. The climate is cool and foggy and water used per acre is small. Based on records secured in various parts of the area, the average use in north Montalvo and Oxnard areas

* Compare with table on page 220.

is 1.03 acre-feet per acre per year, in south Montalvo area 1.08 and in Oxnard Plain 0.82. The average use over the entire area is estimated at 0.90 acre-feet per acre per year. The water table is under pressure over a large part of the area and deep percolation from irrigation can not reach the water table, hence the gross draft is the draft on the underground water but this is not true of the Montalvo area.

The surplus water from irrigation in the pressure area penetrates to the surface ground water which is highly impregnated with salts and can not be used. This is removed by surface drains into the ocean.

Citrus trees use more water than beans, beets or truck and if groves replace these crops the draft will be increased. However, the use by citrus is estimated at only 1.00 acre-foot in the Oxnard Plain.

Water Supply

The principal supply is underflow from Santa Clara Valley and percolation in the river bed in crossing the absorbent Montalvo area. Next in importance is rainfall penetration on the Montalvo area and West Las Posas area, and next, percolation of run-off from the northern mountains. Other miscellaneous small supplies were neglected in calculations.

Analysis of the supply to and demand on this area was made for the 40-year period beginning with fall of 1892 on the assumption that all the land presently irrigated in Santa Clara Valley had been irrigated during the period thereby decreasing the historical supply, and that all the land presently irrigated in the Coastal Plain had been irrigated during the period thereby increasing the historical draft, and that the draft during wet years would be the same per acre irrigated as during the period of investigation. The underground basin was treated as a reservoir. On Plate XXIV the changes of content are shown graphically. Starting with the reservoir full this shows a hypothetical decrease in content of 257,000 acre-feet during the period. It should be stated, however, that it is unlikely that the draft would be as large during normal or above normal years of rainfall as it averaged during the investigation in which four of the five years were years of drought. If this supposition proves to be correct the foregoing estimate of decrease and calculated shortage in the following table are too large.

The result of the calculations is summarized in the following table.

TABLE 22

COASTAL PLAIN

Present Average Annual Supply and Demand Spring 1892, to Fall, 1932

	Acre-feet	
Supply—		
Percolation in Santa Clara River across Montalvo Area	22,700	
Underflow from Santa Clara Valley	5,000	
Rainfall penetration in Montalvo and Los Posas Areas	5,400	
Imported from Santa Paula Basin	700	
		33,800
Demand—		
Agriculture, 42,400 acres at 0.90	38,200	
Domestic—		
1,200 acres at 1.50 (Oxnard)	1,800	
70 acres at 1.20 (Hueneme)	100	
		40,100
Shortage		6,300

The "shortage" is the average annual decrease in content of the underground reservoir through two periods of deficient rainfall and one of surplus. Obviously the average shortage is some lesser quantity; i.e., the loss over a period embracing one wet and only one dry period. The 25-year period from 1893 to 1918 completed a wet and dry cycle and the shortage for that period is estimated to average 1800 acre-feet annually instead of the 6300 acre-feet as shown by the tabulation. In other words over a long period and with present conditions these estimates indicate practically a balance between supply and demand in the Oxnard Plain. If a shortage exists it is apparently small and might be made up by decrease in draft during wet years, or for the present draft could be readily taken care of at a small expense, but additional draft as new acreage is developed would require more expensive development of conservation. However, the underground supply of the plain may be jeopardized by intrusion of salt water from the ocean as the water table lowers during the long dry cycles such as that existing at present.

Marine Intrusion

If draft had been as great during the past forty years as it was during the investigation the water table would now be at a considerable distance below sea level over most of Oxnard Plain. Whether this would allow intrusion of water from the ocean into the pumping strata is not known. It would depend on how low the water table fell and on whether the strata are blanketed off shore with sufficient tight material to prevent inflow. In some places in the State where the water table is below sea level, intrusion has occurred and in some others it has not. It is believed that it constitutes a threat which should be guarded against by artificial replenishment of the basin during the dry period. If sufficient recharge is made during such periods, it can be safely assumed that the long-time shortage will be provided for.

The water table slopes from the end of South Mountain west and south to the sea. To maintain it at a gradient toward the shore line it was assumed that the total content above sea level must not be allowed to fall below 6000 acre-feet. The total reservoir content between sea level and "Full reservoir" as shown on Plate XXIV, opposite page 106, is calculated to be 91,000 acre-feet, leaving 85,000 acre-feet of net safe reservoir capacity. It is possible that the water table could be drawn somewhat below the arbitrarily selected level for periods of a few years without detrimental results.

Reference to Plate XXIV indicates that for present draft, during the dry period since 1922 there would have been an average of 9000 acre-feet of artificial recharge per annum required to maintain the water table at the level at which it is assumed that intrusion of salt water would be prevented. Maintenance at this level would result in overcharge of the basin during the wet periods or in waste of water which would have otherwise percolated during such periods.

Ultimate development of 5400 acres additional would require, at the assumed net use of .90 acre-feet per acre, about 5000 acre-feet additional per year. Ultimate development in Santa Clara Valley would demand 11,000 acre-feet per year in addition to present demand. It is true that this additional demand in Santa Clara Valley would

result in 11,000 acre-feet less waste into the ocean on the average but this decrease would largely be made up by increased natural percolation of floods so that the net result of ultimate development in Santa Clara Valley and Coastal Plain would be, it is calculated, a need of an auxiliary supply to the Coastal Plain averging 17,000 acre-feet per annum for the years of the dry cycle since 1922 to maintain a pressure gradient to the ocean and exclude ocean water.

Conclusion

Recharge of the underground water supply of the Coastal Plain is slightly deficient over a 40-year period such as that since 1892, for a draft such as occurred during the dry years of the investigation. If such a period repeats itself and draft continues at that rate per acre the water table would be considerably below sea level at the end of the period. It is estimated that with such a draft it would require an average additional annual recharge of 9000 acre-feet at the present time to sustain the water table during dry cycles and that there will be eventually required an average annual augmented recharge of 17,000 acre-feet to guard against possibility of marine intrusion. If this is taken care of the shortage will be provided for with considerable margin.

CHAPTER XI

COST ESTIMATES OF SURFACE RESERVOIRS

In this chapter are given the results of geological and topographical surveys on the more favorable reservoir sites in the area investigated, together with the results of estimates of cost for various reservoir capacities and types of dams at each site. Locations of reservoirs are given on frontispiece. Exploration at the sites has been much more thorough on Piru Creek than is usual in investigations of this nature because of the controversy caused by occupancy of Los Alamos and Spring Creek sites by the State highway which has brought about a desire to determine whether additional costs for conservation will be incurred due to this occupancy. As Sespe Creek sites offer an alternate conservation to Piru Creek sites these were also estimated in similar detail but as geological reports indicated simple foundation conditions at the dam sites on Sespe Creek the foundations were not explored. No exploration was done on Matilija site in the Ventura River system but at Dunshee site on Coyote Creek, also a tributary to Ventura River, the abutments were trenched. It is believed that the excavation in the bottom can be fairly approximated from this. At Camarillo site on Conejo Creek borings were made.

On Plates XXV and XXVI are curves giving total cost and cost per acre-foot of capacity of various types and capacities, which summarize graphically all the information as to cost given in this chapter. Accompanying the description of each reservoir is a plate showing the general layout of one height of the most economic type of dam on which detailed estimates are based.

In Chapter XIII the cost per acre-foot of yield is given which, as all dams are considered safe, is the ultimate criterion of comparative desirability.

Los Alamos Reservoir

Los Alamos Reservoir site is located on Piru Creek in Sec. 3, T. 6 N., R. 18 W., and Secs. 27, 33 and 34, T. 7 N., R. 18 W., S. B. B. and M. in Los Angeles County. The dam site for the reservoir is located in the N.E. ¼ of Sec. 3 about 400 feet south of the north line of the section.

A topographic survey of the reservoir site was made by the State in March, 1933, and a map was drawn from this survey at a scale of one inch equals 400 feet, with a contour interval of 10 feet. The water surface areas measured from this map and the capacities of the reservoir computed from them are shown in the following table:

PLATE XXV

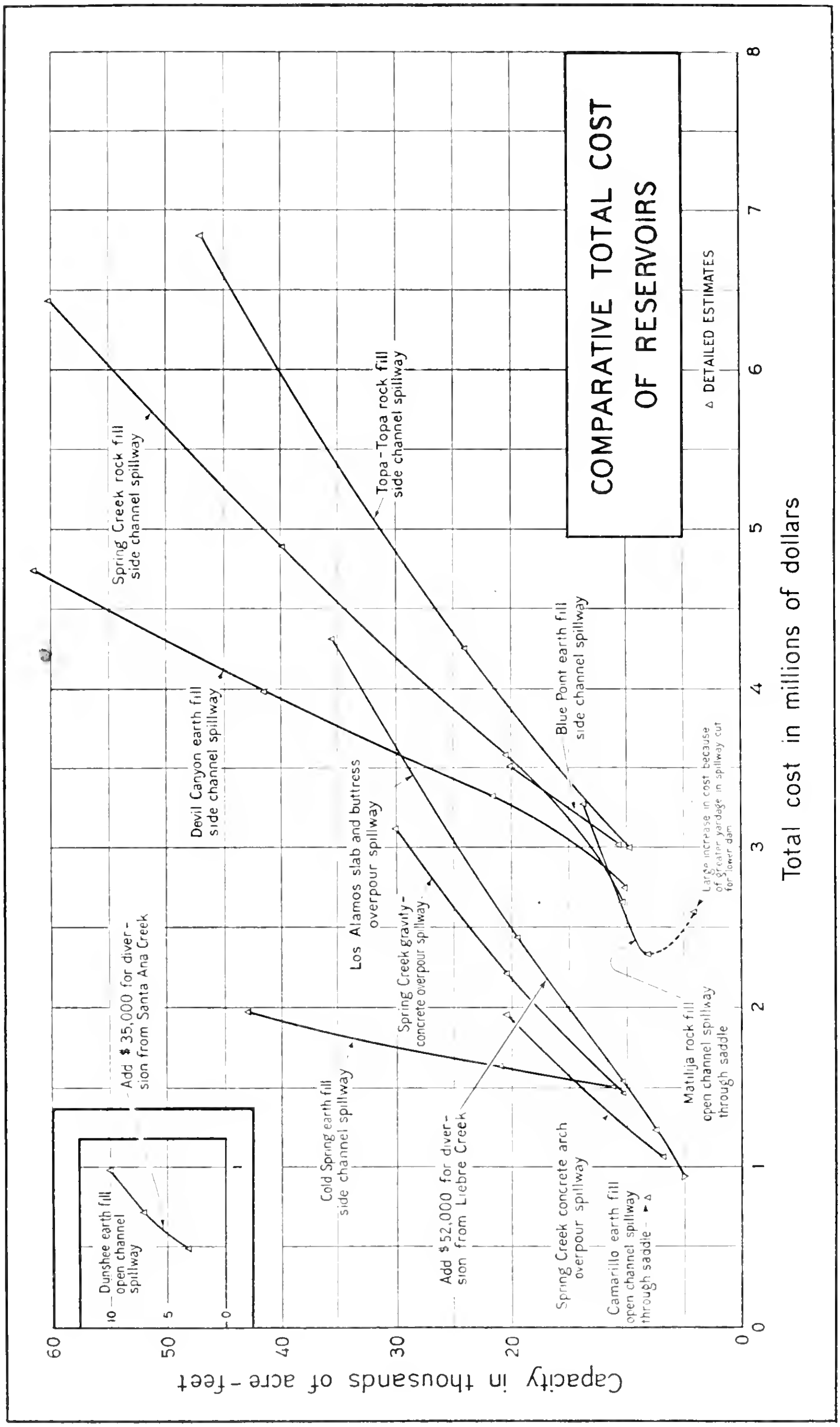

COMPARATIVE TOTAL COST OF RESERVOIRS
△ DETAILED ESTIMATES
Total cost in millions of dollars
Capacity in thousands of acre-feet
Topa-Topa rock fill side channel spillway
Spring Creek rock fill side channel spillway
Devil Canyon earth fill side channel spillway
Blue Point earth fill side channel spillway
Los Alamos slab and buttress overpour spillway
Spring Creek gravity-concrete overpour spillway
Large increase in cost because of greater yardage in spillway cut for lower dam
Matilija rock fill open channel spillway through saddle
Cold Spring earth fill side channel spillway
Add $ 35,000 for diversion from Santa Ana Creek
Add $ 52,000 for diversion from Liebre Creek
Spring Creek concrete arch overpour spillway
Camarillo earth fill open channel spillway through saddle
Dunshee earth fill open channel spillway
0
1
2
3
4
5
6
7
8
10
20
30
40
50
60

TABLE 23

AREAS AND CAPACITIES OF LOS ALAMOS RESERVOIR

Elevation of water surface, in feet, U. S. G. S. datum	Area of water surface, in acres	Capacity of reservoir, in acre-feet
2,270	0	0
2,280	1	6
2,290	8	50
2,300	19	178
2,310	39	468
2,320	65	990
2,330	96	1,790
2,340	127	2,910
2,350	156	4,320
2,360	188	6,050
2,370	218	8,090
2,380	249	10,400
2,390	282	13,100
2,400	316	16,100
2,410	348	19,400
2,420	373	23,000
2,430	403	26,900
2,440	430	31,000
2,450	463	35,500

The survey of the dam site was made by the State in April, 1933. A topographic map drawn from this survey at a scale of one inch equals 50 feet, with a contour interval of 10 feet, was used in laying out and estimating the costs of dams of several heights.

The geology of the region and the dam site has been studied by Dr. Charles P. Berkey and Paul F. Kerr, Hyde Forbes, and Chester Marliave. Exploration at the dam site consists of drilling six holes in the stream channel to determine the depth of gravel fill and character of the underlying rock. The following data on the geology of the reservoir and dam site are taken from a report by Chester Marliave:

The region in the vicinity of the Los Alamos Dam site is composed almost entirely of sedimentary deposits of Tertiary age. Thick beds of siliceous and clay shales predominate with lesser amounts of interbedded sandstone. There are some major faults in the region, and the sediments for the most part are inclined at rather steep angles.

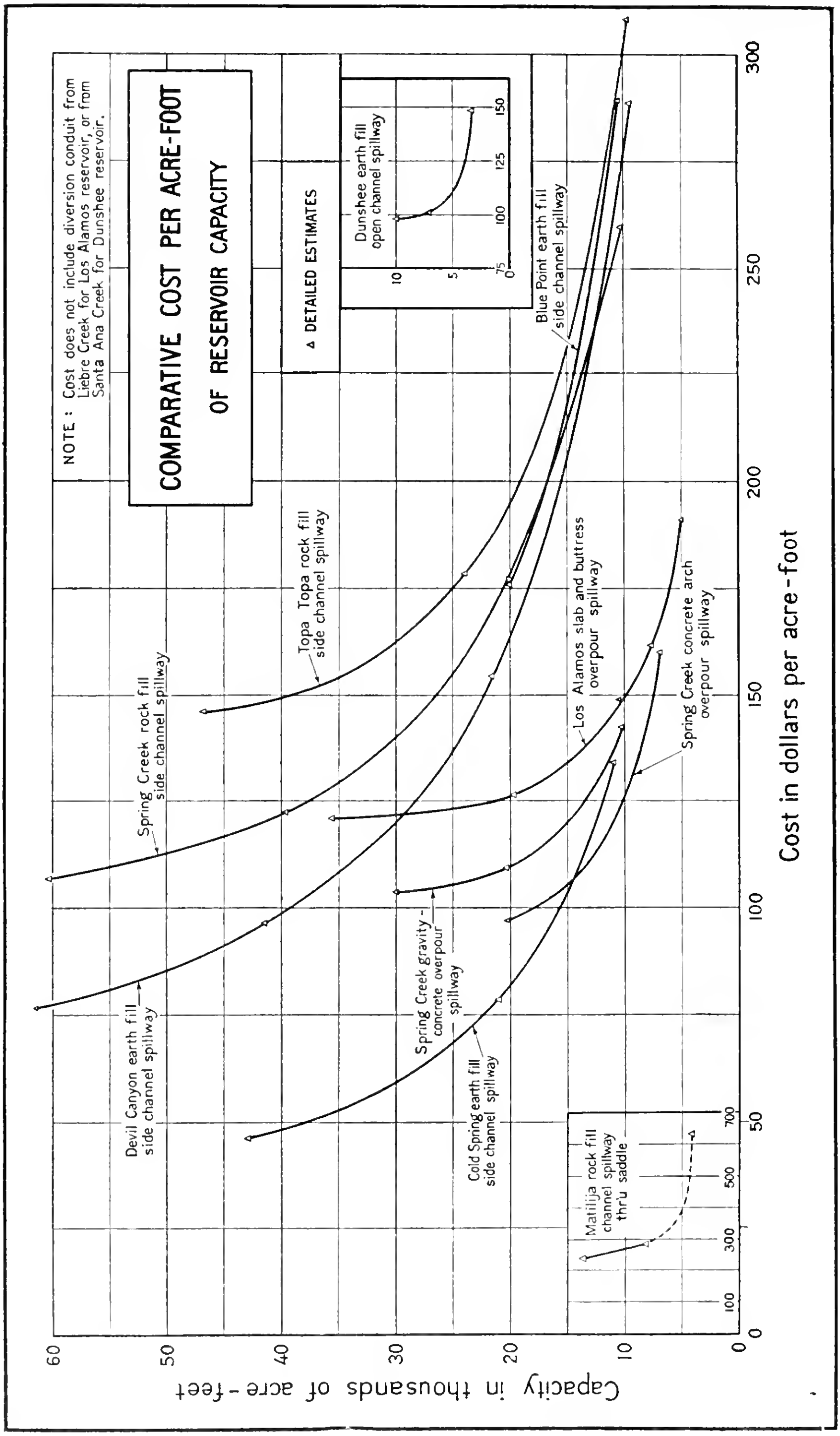
The geology at the dam site has been carefully examined and measurements of dip and strike noted, as well as the character of the outcrops and amounts of loose overburden.

The constriction in the canyon that was examined is about 1200 feet in length. Along this stretch there are several locations that are topographically suitable for the construction of a dam.

The bedrock throughout this portion of the canyon is a thickly laminated, thin bedded, siliceous shale, all dipping uniformly upstream at about 50 degrees from the horizontal with the beds crossing the stream at various angles depending upon the course of the canyon. The rock is hard and slaty, the laminations for the most part varying between $\frac{1}{2}$ inch and 6 inches in thickness. In several horizons the shales are thin bedded and weather on the surface to dark colored finely divided particles, but for the most part the beds of shale have strata averaging several inches in thickness. Interspersed through the bedding are several strata of calcareous sandstone which generally occur in single layers, seldom over 12 inches in thickness.

The fractured condition of the shale upon exposure to the elements is one of the poor qualities of the formation. Where the beds are

PLATE XXVI


NOTE: Cost does not include diversion conduit from Liebre Creek for Los Alamos reservoir, or from Santa Ana Creek for Dunshee reservoir.
COMPARATIVE COST PER ACRE-FOOT OF RESERVOIR CAPACITY
△ DETAILED ESTIMATES
Dunshee earth fill open channel spillway
Blue Point earth fill side channel spillway
Topa Topa rock fill side channel spillway
Spring Creek rock fill side channel spillway
Los Alamos slab and buttress overpour spillway
Spring Creek concrete arch overpour spillway
Devil Canyon earth fill side channel spillway
Spring Creek gravity - concrete overpour spillway
Cold Spring earth fill side channel spillway
Matilija rock fill channel spillway thru saddle
Capacity in thousands of acre-feet
Cost in dollars per acre-foot
0
10
20
30
40
50
60
50
100
150
200
250
300
75
100
125
150
5
10
300
500
700

confined they are compacted and generally tight, due in part to their monoclinal structure which has not undergone much distortion or bending. However, where they are exposed along the canyon walls the strata are released from compression and tend to open. This, together with direct exposure to the elements, allows free access for percolating water which greatly increases the mechanical action through swelling the clay particles by allowing hydrostatic pressure from the encased water, and by frost action. The outcropping bluffs of shale are therefore somewhat unstable and tend to break down mechanically. Occasionally one or two thick strata of siliceous shale or a hard stratum of sandstone resists erosion more than the thinner laminated beds and forms a protective capping which results in steplike weathering along the stratification.

At the Los Alamos site there are numerous outcropping ridges which are the result of this unevening weathering of the beds, and a first impression is that the bluffs represent hard ribs and the talus covered slopes represent soft ribs. Upon close examination of the strata along the canyon there appears to be little difference in the character of the rock except in the step like weathering which on account of the attitude of the beds is inclined.

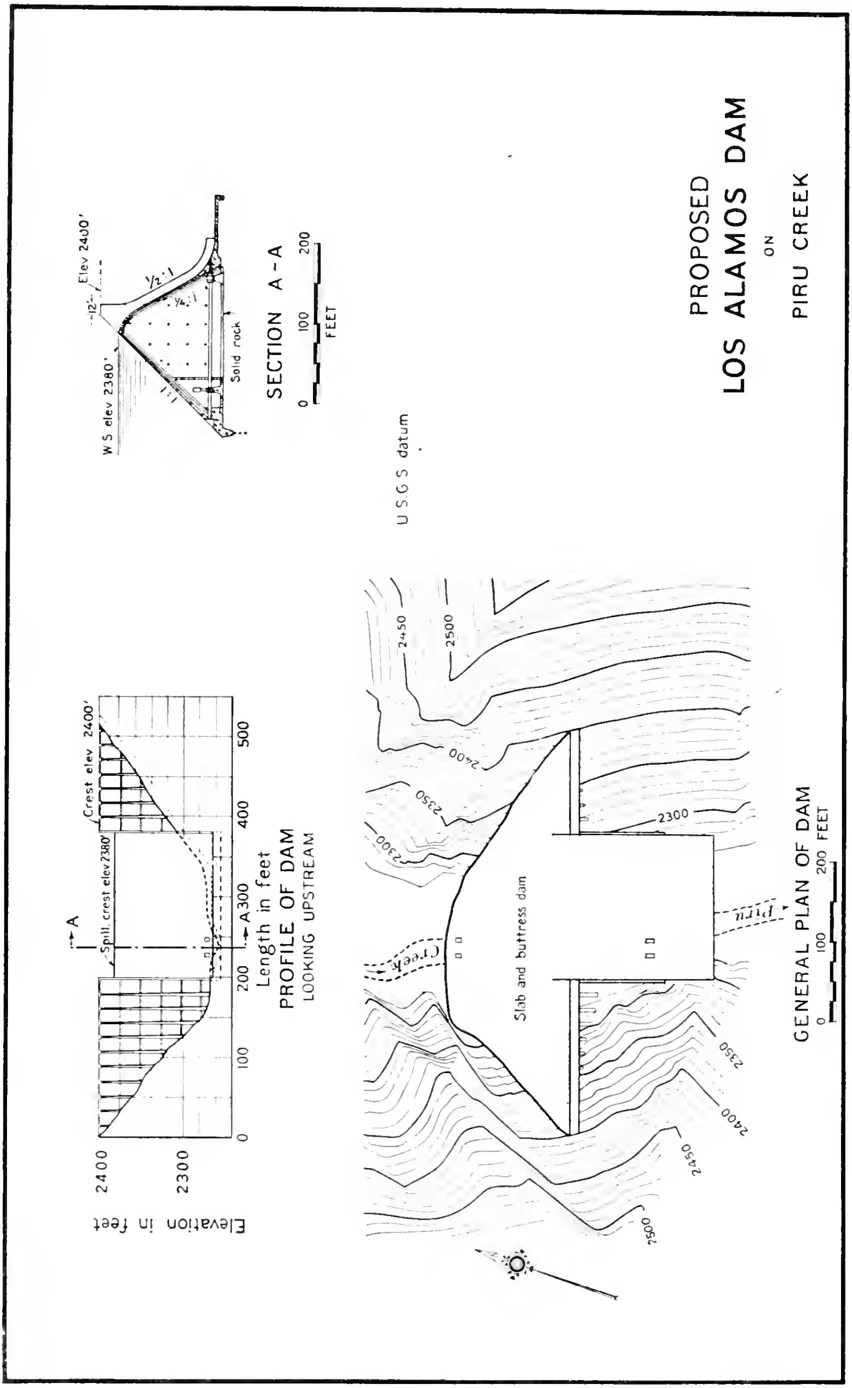
As heretofore noted the outcropping ridges are more fractured than the stream bed outcrops. This is quite noticeable upon careful examination of the ends of the strata along the vertical sides of the ridges where much cross fracturing may be observed. This cross fracturing is detrimental to the integrity of the ridges for use as foundation abutments for rigid structures. The ridges are liable to crush under concentrated loading because of lack of compactness and of surrounding support.

Permeability of the bedrock is an important factor in choosing a type of dam for this location. The outcropping ridges would undoubtedly leak considerably on account of their uncompressed condition and cross fracturing. There is little doubt but that these strata tighten up with depth and that a cut-off could be obtained that would be satisfactory for any type of dam. Seepage through the foundation would have to be carefully considered in case of a concrete gravity dam on account of uplift, and a location selected where the formation is compact, or else resort must be had to heavy stripping where the cross fracturing is prevalent.

The solubility of the bedrock should also be noted. For the most part the shales are siliceous and therefore insoluble, but some of the partings and fractures contain gypsum. This may be seen as a white coating on numerous damp rock exposures. At one place the solution from the rock has fallen upon the fragmental talus below the cliff and cemented it into large blocks over four feet in diameter resembling agglomerate. The solubility of the rock is not considered serious, but it would probably cause an uncementing of the cross fracturing in the ridges through reservoir seepage, thereby weakening their stability for sustaining concentrated loads.

Grouting would have to be resorted to in order to obtain a cut-off for any type of dam. The shale beneath the channel section should not take much grout, but the hill slopes should take large amounts.

PLATE XXVII



PROPOSED
LOS ALAMOS DAM
ON
PIRU CREEK
W S elev 2380'
Elev 2400'
Solid rock
SECTION A-A
FEET
U.S.G.S datum
Elevation in feet
Crest elev 2400'
Spill crest elev 2380'
Length in feet
PROFILE OF DAM
LOOKING UPSTREAM
Slab and buttress dam
Piru
Creek
GENERAL PLAN OF DAM
FEET

An earth fill, rock fill, gravity concrete, or slab and buttress dam could be constructed at this site. Materials are available in the vicinity for the first two types but the construction of a spillway for these types would present some difficulties. A gravity concrete dam would require a large section since it would be necessary to design it for uplift over the entire base. There is also some doubt if sufficient aggregates for the amount of concrete required for this type of dam are available in the reservoir site. The site is well adapted to the slab and buttress type of dam and there is sufficient aggregate available in the reservoir site for its construction. This type was therefore selected for comparative cost estimates. The layout for a 135 foot dam is shown on Plate XXVII.

The crest line of the dam would be about 400 feet south of the township line between Twps. 6 and 7 N. In this location the dam would be below the prominent outcropping strata and on relatively uniform topography. The dam would be straight in plan and the portion over the present stream bed would be of the overflow spillway type. This spillway section would be 180 feet in length and its crest would be 20 feet below the top of the other portions of the dam. With this length of spillway it is estimated that a flood of 61,000 second-feet, the crest flow of a flood which may occur once in 1000 years on the average, would pass the dam without over-topping the nonoverflow sections. No gates would be placed in the spillway and the normal water surface would therefore be at the elevation of the spillway crest. The nonoverflow sections of the dam would have crest widths of 12 feet. The upstream face of the dam would have a slope of approximately 1:1 and the downstream side of the buttresses, except under the spillway, would be vertical for 48 feet from the top and then have a slope of $\frac{1}{4}$:1. The downstream face of the spillway section would be a concrete slab on a slope of $\frac{1}{2}$:1. At the intersection of this slab with the stream bed there would be a concrete bucket, and downstream from this bucket the stream channel would be paved with 2 feet of concrete to a point about 85 feet from the toes of the buttresses. The buttresses would be spaced at 18-foot centers. They would be 18 inches thick at the top and increase 4 inches in thickness in each 12 feet of depth. They would be stiffened by 18-inch by 24-inch horizontal concrete struts at about 24-foot centers in both vertical and horizontal directions. The upstream slab would be 15 inches thick at the top and increase $3\frac{1}{2}$ inches in thickness in each 12-foot depth of dam. The downstream slab of the spillway would be 18 inches thick throughout. A guide wall 10 feet high and 3 feet thick would be constructed along each side of the spillway on the downstream side.

There would be two 36-inch steel outlet pipes through the dam. Each of these outlets would be equipped with a slide gate near the upstream face of the dam and a needle valve, for regulating the flow, would be placed at the outlet end.

There are in the reservoir site a number of improvements which would be flooded by the construction of a dam. These comprise a steel tower transmission line, 26-inch and 22-inch gas pipe lines, an 8-inch oil pipe line, a small water pipe line, a telephone line, and the new State highway from Los Angeles to Bakersfield. In making the estimates, the costs of relocating all of these improvements, except the

highway, so that they would not be interfered with by the water in the reservoir, have been included.

It is estimated that for the construction of the dam the removal of residual shale over the left abutment to a depth of 6 feet normal to surface and the removal of 15 feet of loose material in the stream bed would be required to reach a firm shale foundation. Additional excavation into this firm shale for buttress footings and a cut-off wall at the upstream toe would also be required. The rock beneath the cut-off wall would have to be sealed by pressure grouting. In estimating the cost of the concrete it has been assumed that there is sufficient aggregate within the reservoir site and that the cement would be hauled by truck from the railroad at Castaic.

The estimated total costs for the reservoirs with all heights of dam studied are given in the following table.

TABLE 24

COSTS OF LOS ALAMOS RESERVOIRS WITH SLAB AND BUTTRESS DAMS

Crest elevation, in feet, U. S. G. S. datum	Water surface elevation, in feet	Capacity of reservoir, in acre-feet	Capital cost	Cost per acre-foot of capacity
2,374	2,354	5,000	$952,600	$191
2,387.5	2,367.5	7,560	1,224,600	162
[1] 2,400	2,380	10,400	1,549,000	149
2,430	2,410	19,400	2,448,800	126
2,470	2,450	35,500	4,309,500	121

[1] A detailed cost estimate of this reservoir is given on page 227. The items and unit prices shown in this estimate are the same as for other capacities.

Liebre Creek Diversion to Los Alamos Reservoir.—Water from Liebre Creek, which enters Piru Creek below Los Alamos dam site, may be diverted over a low divide into the reservoir site. The discharge would be diverted from both the main channel and its West Fork by low dams and carried in concrete lined canals and flumes along the stream canyons to approximately opposite the point where the State highway crosses the divide between the Liebre and Los Alamos Creek watersheds. It would then be carried across Liebre Creek in a flume and through a culvert under the highway; thence through the crest of the divide to a spillway into the reservoir. The West Fork canal would have a capacity of 40 second-feet and the Liebre Creek canal a capacity of 60 second-feet. The total cost of this diversion is estimated at $51,960 and the detail is given on page 228.

Spring Creek Reservoir

Spring Creek Reservoir site is located on Piru Creek in Secs. 1, 2, 11, 12, 13 and 14, T. 6 N., R. 18 W., S. B. B. and M., in Los Angeles County. The dam site is located in the SE$\frac{1}{4}$ or Sec. 14.

A topographic survey of the reservoir site was made by the Fairchild Aerial Surveys Incorporated for the Santa Clara Water Conservation District and a map was drawn from this survey at a scale of one inch equals 400 feet, with a contour interval of 20 feet. The water surface areas measured from this map and the capacities of the reservoir computed from them are shown in the following table:

TABLE 25

AREAS AND CAPACITIES OF SPRING CREEK RESERVOIR

Elevation of water surface, in feet, U. S. G. S. datum	Area of water surface, in acres	Capacity of reservoir, in acre-feet
2,000	0	0
2,020	6	60
2,040	48	600
2,060	77	1,850
2,080	109	3,710
2,100	150	6,700
2,120	202	10,220
2,140	250	14,740
2,160	296	20,200
2,180	340	26 560
2,200	386	33,820
2,220	431	41,990
2,240	476	51,060
2,260	521	61,030
2,280	566	71,900
2,300	611	83,670

The survey of the dam site was made by the State in March, 1933. A topographic map drawn from this survey at a scale of one inch equals 50 feet, with a contour interval of 5 feet, was used in laying out and estimating the costs of dams of several heights and types.

The geology of the reservoir and dam sites has been studied by Dr. Charles P. Berkey and Paul F. Kerr, Hyde Forbes, and Chester Marliave. The exploratory work that has been done at the dam site is drilling five holes across the stream bed to determine the depth of gravels and character of bedrock. Where these holes penetrated bedrock diamond drills were used and the rock was cored. The following data on the geology of the site are from the report by Chester Marliave:

For many miles upstream from the Spring Creek site the course of Piru Creek cuts through a thick series of clay shale beds, which have a general east and west trend, and in the vicinity of the reservoir site dip toward the north at about 40 degrees from the horizontal. The reservoir lies for the most part within these clay shales.

Near the lower end of the reservoir the stream enters a constriction in the mountains which is composed of conglomerate interbedded with some sandstone layers. After passing through this formation for a distance of 1000 feet, the rocks change to granites which continue for several miles downstream from the dam site.

The shales and conglomerates are sedimentary deposits, while the granite is an igneous intrusion of great depth. The shales are younger than the conglomerates and seem to rest unconformably upon them although there is evidence of faulting or folding along their contact in the reservoir site. There is a fault between the conglomerates and the granite and the granite is badly crushed and altered for several hundred feet downstream from the contact.

The fault is a continuous one and is recorded on the Fault Map of California which was published by the Seismological Society of America. Little is known concerning the activity of this fault, but it is considered inactive. The San Andreas Fault, however, which is known to be active, runs parallel with it about eight miles to the east.

The reservoir site lies almost entirely within the clay shales which rest unconformably against the thick beds of compact conglomerate.

There would be no loss of stored water through the bottom or sides of the reservoir, as it is lined with impervious formations.

The bedrock formations in the vicinity of the dam site, as previously noted, consist of clay shales, conglomerates, and granite. The foundation rock which occurs at the dam site selected, consists almost entirely of conglomerate and associated pebbly sandstone. The other formations, however, will be briefly described.

The clay shales of the reservoir are rather thin bedded and readily break down, yielding a thick clay soil. They are an unbroken formation and can be followed up the canyon for several miles in a uniformly inclined attitude. There are several horizons included within the beds where sandstones predominate but they represent a small proportion of the series.

The granite which is found downstream from the canyon constriction is badly altered and decomposed. It appears to be crushed along the fault contact and for several hundred feet more downstream. The granite was followed down the canyon for about $3\frac{1}{2}$ miles before rock was encountered which might be utilized in a rock fill dam. None was encountered that could be crushed for concrete aggregate.

The conglomerate which forms the foundation rock at the proposed dam site is exceptionally hard and well cemented. It is composed of both angular and waterworn pebbles of granite, gneiss, quartz, and feldspar firmly cemented together. Some of the coarse granitic cobbles in it are minutely fractured, but where encased in the siliceous matrix do not materially weaken the strength of the rock mass. Like all sediments the rock has bedding planes, and in this case the dip is about 50 degrees to the north, while the bedding planes have a general northeast strike crossing the channel diagonally.

From the logs of the drill holes, it is estimated that the maximum depth of gravels is about 60 feet below present stream bed and that the thread of the bedrock channel lies somewhat to the north of the surface channel, under the bench of gravel and talus that now rests against the right-hand side of the canyon.

The cross-fracturing in the conglomerate is one of the poor qualities of the formation. Where the rock is massive it is generally fresh and void of fracturing and even the bedding planes are sometimes hard to distinguish; but where the cross-fracturing exists, with planes of fracture traversing the rock and intersecting the bedding stratification, the elements have access to the rock mass, and it weathers and disintegrates. This is particularly true of certain ridges where the conglomerate has been attacked and has ravelled down onto the talus slopes leaving a residual mass of conglomerate pebbles.

The conglomerate, where fresh, is insoluble and not subject to removal by solution. Crushed, fractured, and disintegrated conglomerate may be attacked by water which would help to break down the cementing material of the matrix, but the firm compact rock would be free from this action.

The conglomerate where intact is impermeable. The thick strata are massive and firmly cemented and exhibit no cavernous openings or porous unconsolidated lenses. Certain bedding planes, however, appear to be open, but this is due to surface erosion along these seams which may be augmented by gravitational movement in conjunction with

cross-bedding. It is believed that the cross-fracturing which is occasionally seen as thin fracture seams on the surface will tighten up or disappear with increased depth.

The right abutment of the dam is a high massive cliff extending several hundred feet above the top of the proposed dam. The rock is almost all fresh and free of open bedding planes. The structure has a uniform monoclinal dip and appears to be continuous across the canyon. Cross-fracturing is not prevalent on this side of the canyon. One small fault or slip has been noted, but this is only a tight fracture showing a 5-foot displacement.

The left abutment of the dam is composed of the same conglomerate beds as are exposed on the right side of the canyon. There has been considerable erosion along some of the bedding planes on this side, and cross-fracturing seems to have assisted in the breaking up of the rock, especially along the higher elevations.

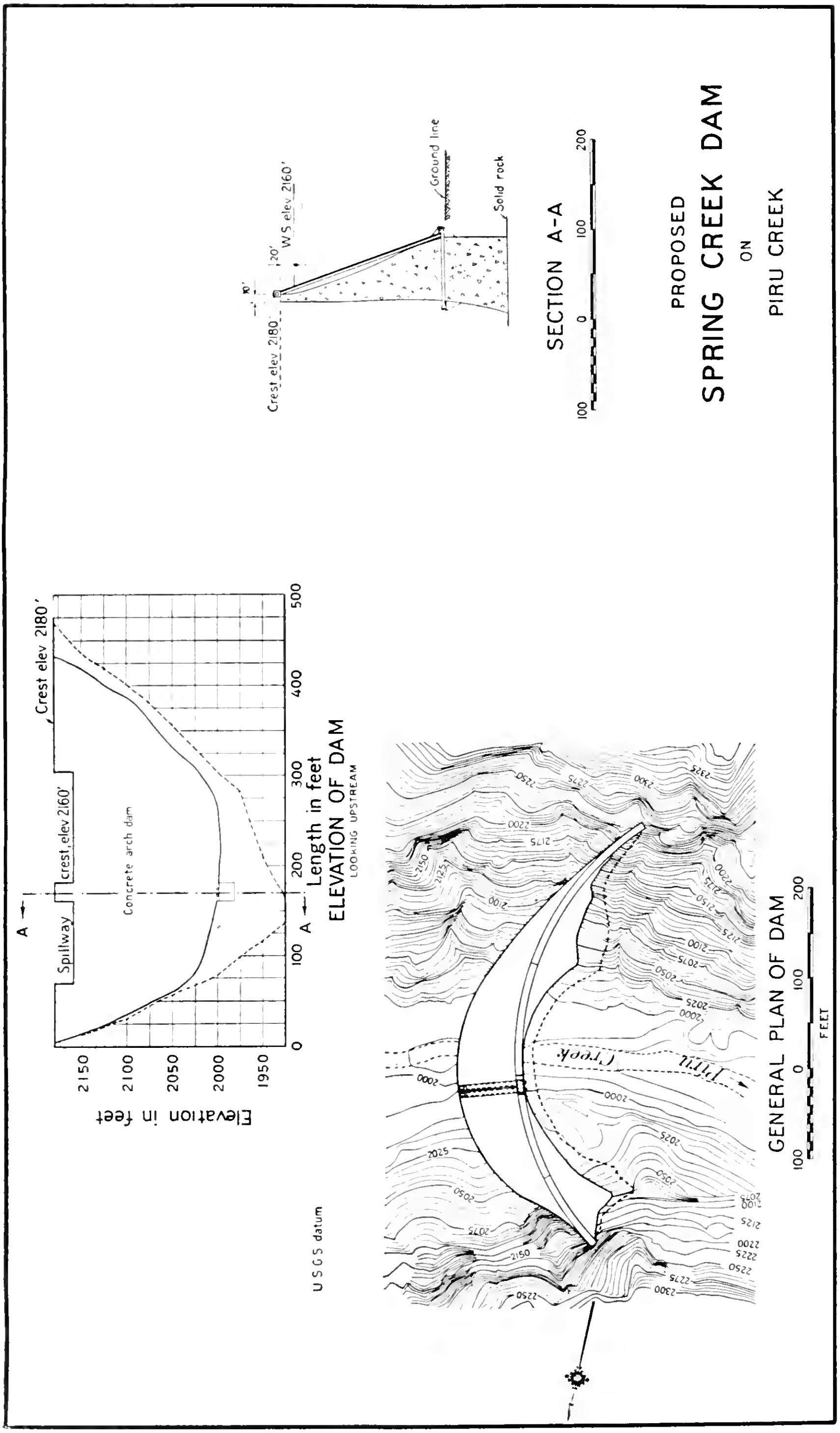
Along the lower slopes of the canyon adjacent to the bottom, weathering has penetrated the bedding planes quite appreciably and a cut-off would require removal of these outer layers in order to reach compact rock strata. This would be quite necessary in case of an arch dam in order to insure stability of the foundation to take thrust loading.

At a point opposite the drill holes, on the left side of the canyon, at an elevation of 150 to 200 feet above the stream bed, there are several fracture planes, one of which at contour 2150 dips toward the creek at 45 degrees and another of which at contour 2100 dips into the hill at an average of 14 degrees. These fractures truncate the prominent ridge of rock on the left abutment and contain several inches of brecciated material along the fracture seams. The rock above these fractures on this ridge is unsatisfactory foundation rock for any type of dam and would have to be removed. A ridge 150 feet farther downstream on the same side of the canyon is likewise badly fractured and unstable, and the rock is of poor quality. The rock upstream from the first mentioned ridge is best suited for the abutment of a high dam.

The channel section is covered with gravel and on the right side upstream from the drill holes there is considerable talus which has ravelled down from the high cliffs above. The somewhat open and weathered bedding planes that stand out along the edge of the gravels on the left side of the canyon appear to be tight on the right wall of the dam site so it is concluded that they become tight under the stream gravels. It is a fact that bedrock in the bottom of stream channels is generally fresh and free from open seams. Downstream from the drill holes there is a sheer bluff of conglomerate on the right hand side, but on the left side there is a talus slope at the foot of which is an accumulation of large detrital material.

A concrete arch, gravity concrete, or rock fill dam could be constructed at this site. Rock for the rock fill dam is available in the vicinity but aggregates for concrete dams and for the concrete facing on the rock fill dam would have to be hauled for a distance of about five miles. Geological conditions at the dam site give only limited space within which each of these types of dam could be constructed. Esti-

PLATE XXVIII



PROPOSED
SPRING CREEK DAM
ON
PIRU CREEK

mates have been made for all three types and these estimates, together with brief descriptions of the dams, are given herewith. Layout of a concrete arch dam 185 feet in height is shown on Plate XXVIII.

Concrete Arch Dam—Estimates have been made of the costs of reservoirs with concrete arch dams 125, 185, 240 and 283 feet in height. All of these would be located in approximately the same position in the canyon. This position is governed by minor faults and fractures in the rock above and below the site. Each dam would be of the variable radius type and would be located to fit the solid rock best adapted for a foundation for its construction. For the two higher dams, a gravity concrete abutment would be constructed at the left end of the arch section. The two lower dams would be full arches between the solid rock of the canyon walls. For the two lower dams, the spillway would be placed in the crest of the dam. This spillway would be 218 feet in length and its crest would be 20 feet below the top of the nonoverflow sections of the dam. With this length of spillway, a flow of 73,000 second-feet, the estimated crest flow of a flood which may occur once in 1000 years on the average, would pass the dam without overtopping the nonoverflow sections. No gates would be placed in the spillway and the normal maximum water surface would therefore be at the elevation of the spillway crest. The nonoverflow sections of the dam would have crest widths of 10 feet.

For the two higher dams the spillway would be of the shaft and tunnel type with the inlet structure located on the right side of the creek on the northerly side of the first bend above the dam. The tunnel would extend through this bend to a point about 500 feet below the dam. The weir would be circular in plan with a diameter of about 100 feet between the spillway crests. The shaft would taper from this diameter to 28.2 feet for the highest dam and 29.6 for the next to highest dam. These latter diameters would be those of the outlet tunnels. The crest of the spillway would be 314 feet in length and at an elevation 17 feet below the crest of the arch dam. This spillway would also pass 73,000 second-feet without the water overtopping the concrete arch dams.

The outlets through the dams would consist of two 36-inch steel pipes embedded in the concrete. Flow through each outlet would be controlled by a needle valve at the downstream face of the dam. Each outlet would also be equipped with an emergency roller type gate at the inlet end. This gate would be operated from the top of the dam and protected by steel trash racks set in a closed concrete structure extending to the top of the dam.

In making the estimates, it was assumed that 10 to 75 feet of rock would be removed from the abutments and 15 to 80 feet of talus, gravel and decomposed rock from the stream bed. The rock beneath the foundation of the dam would also be sealed by pressure grouting. In estimating the cost of the concrete, it has been assumed that the aggregates would be hauled from a pit five miles from the site and that the cement would be hauled by truck from the railroad at Castaic. The land in the reservoir site is all government owned and it has been assumed that there would be no cost for its acquisition. There is, however, a steel tower transmission line crossing the site, the cost of the

relocation of which has been included in the estimates. The new State highway from Los Angeles to Bakersfield passes through a large portion of the site but the cost of its relocation has not been included in the estimates.

The estimated total costs for the reservoirs with all heights of concrete arch dams studied are given in the following table:

TABLE 26

COSTS OF SPRING CREEK RESERVOIRS WITH CONCRETE ARCH DAMS

Crest elevation, in feet, U. S. G. S. datum	Water surface elevation, in feet	Capacity of reservoir, in acre-feet	Capital cost	Cost per acre-foot of capacity
2,120	2,100	6,700	$1,069,800	$160
[1]2,180	2,160	20,200	1,954,600	97
2,235	2,218	41,000	4,350,500	106
[2]2,278	2,261	61,500	5,464,900	89

[1]A detailed cost estimate of this reservoir is given on page 228. The same items and similar unit prices were used for the next lower dam.

[2]A detailed cost estimate of this reservoir is given on page 229. The same items and similar unit prices were used for the next lower dam.

Gravity Concrete Dam—Estimates have been made of the costs of reservoirs with gravity concrete dams 145, 185, 214.5, 237 and 280 feet in height. All of these dams would be located with the downstream toe in the same position. This position is governed by a minor fracture in the rock just below the foundation site. The location of the upstream face would vary with the height of dam. The dams would be of the gravity concrete type with vertical upstream face and downstream slope of $\frac{3}{4}$:1 starting from the upstream crest line. The crest would be 20 feet in width and there would be an approximately vertical face from the downstream crest line to an intersection with the downstream slope of the dam. For the three lower heights of dam, the spillway would be placed in the crest of the dam. This spillway would be 218 feet in length and its crest would be 20 feet below the top of the nonoverflow sections of the dam. With this length of spillway, a flood of 73,000 second-feet, the estimated crest flow of a flood which may occur once in 1000 years on the average, would pass the dam without overtopping the nonoverflow sections. No gates would be placed in the spillway and the normal maximum water surface would therefore be at the elevation of the spillway crest.

The spillways for the two highest dams would be of the shaft and tunnel type. They would be the same spillways which have previously been described for the concrete arch dams of approximately the same heights.

The outlets through the dam would consist of two 36-inch steel pipes embedded in the concrete. The gates, valves, trash racks and operating structures would be similar to those previously described for the concrete arch dams.

In making the estimates it was assumed that the necessary excavation on the abutments would vary from 10 to 25 feet normal to the surface and that 15 to 90 feet of talus, gravel, and decomposed rock would be removed from the stream bed. The rock beneath the foundation of the dam would also be sealed by pressure grouting. In

estimating the cost of the concrete, it has been assumed that the aggregates would be hauled from a pit five miles from the site and that the cement would be hauled by truck from the railroad at Castaic. The land in the reservoir site is all government owned and it has been assumed that there would be no cost for its acquisition. The cost has been included, however, for the relocation of a steel tower transmission line crossing the site. No cost has been included in the estimates for the relocation of the new State highway from Los Angeles to Bakersfield which passes through a large portion of the site.

The estimated total costs for the reservoirs with all heights of gravity concrete dams studied are given in the following table:

TABLE 27

COSTS OF SPRING CREEK RESERVOIRS WITH GRAVITY CONCRETE DAMS

Crest elevation, in feet, U. S. G. S. datum	Water surface elevation, in feet	Capacity of reservoir, in acre-feet	Capital cost	Cost per acre-foot of capacity
2,140	2,120	10,200	$1,464,200	$143
[1]2,180	2,160	20,200	2,212,600	110
2,209 5	2,189 5	30,000	3,118,100	104
2,232	2,215	39,800	4,367,300	110
[2]2,275	2,258	60,100	5,952,800	99

[1] A detailed cost estimate of this reservoir is given on page 230. The same items and similar unit prices were used for the next lower dam.

[2] A detailed cost estimate of this reservoir is given on page 231. The same items and similar unit prices were used for the next two lower dams.

Rock Fill Dam—Estimates have been made of the costs of reservoirs with rock fill dams 147, 187, 242. 285 feet in height. All of these dams were located with the center line of the crest in the same position in the canyon. The dam would have a crest width of 15 feet, an upstream slope of 1.3:1, and a downstream slope of 1.4:1. The entire section would be built with rock dumped in place, with the exception of a layer 15 feet in thickness over the entire upstream face which would be constructed of large derrick placed rocks. The upstream face of the dam would be covered with a concrete facing and a heavy concrete cut-off wall along the toe of the dam, extending into bedrock would be constructed. Below this cut-off wall, the foundation rock would be sealed by pressure grouting. The concrete facing would consist of a subslab 12 inches in thickness at the top increasing one inch in thickness in each 25-foot depth of dam. Over this subslab there would be a laminated reinforced concrete facing composed of slabs six inches in thickness. There would be two of these slabs for the first 75-foot depth of dam, and one more slab would be added in each additional 75 feet of depth.

The spillway for all heights of dam would be of the side channel type located on the left side of the canyon with the crest immediately upstream from the crest of the dam. The spillway crest would be 305 feet in length and 22 feet below the crest of the dam. With this length of crest, a flood of 73,000 second-feet, the estimated crest flow of a flood which may occur once in 1000 years on the average, would pass the dam without encroaching on the upper 7 feet of freeboard. No gates would be placed in the spillway and the normal maximum water surface would therefore be at the elevation of the spillway crest.

The spillway channel would have bottom widths increasing from 60 feet at the upstream end to about 100 feet opposite the crest of the dam and would continue with this bottom width through the ridge at the left abutment of the dam. The water on leaving the spillway channel would flow down the rock surface of the ridge and into the creek channel several hundred feet below the dam. The spillway crest and channel would be lined with reinforced concrete.

The creek would be diverted during construction through a concrete lined tunnel 20 feet in diameter under the left abutment of the dam. After the completion of the dam, this tunnel would be used for the outlet from the reservoir. A concrete plug would be placed in the upstream end of the tunnel and a 60-inch steel pipe laid through this plug and extended through the tunnel to its downstream end. A slide gate would be placed in the pipe just downstream from the tunnel plug and a needle valve for regulating the flow would be placed at the outlet end. A trash rack structure would be constructed at the inlet of the tunnel.

In making the estimates, it was assumed that talus and gravel to depths of from 15 to 90 feet would be removed from the stream bed over the entire foundation for the dam and that loose and decomposed rock to depths of from 5 to 60 feet would be removed from the abutments.

In estimating the cost of the concrete, it has been assumed that the aggregates would be hauled from a pit five miles from the site and that the cement would be hauled by truck from the railroad at Castaic. The land in the reservoir site is all goverment owned and it has been assumed that there would be no cost for its acquisition. The cost has been included, however, for the relocation of a steel tower transmission line crossing the site. No cost has been included in the estimates for the relocation of the new State highway from Los Angeles to Bakersfield which passes through a large portion of the site.

The estimated total costs for the reservoirs with all heights of rock fill dams studied are given in the following table:

TABLE 28

COSTS OF SPRING CREEK RESERVOIRS WITH ROCK FILL DAMS

Crest elevation, in feet, U. S. G. S. datum	Water surface elevation, in feet	Capacity of reservoir, in acre-feet	Capital cost	Cost per acre-foot of capacity
2,142	2,120	10,200	$2,652,000	$260
[1]2,182	2,160	20,200	3,578,000	177
2,237	2,215	39,800	4,897,000	123
2,280	2,258	60,100	6,442,000	107

[1]A detailed cost estimate of this reservoir is given on page 232. The same items and similar unit prices were used for the other dams in the table.

Blue Point Reservoir.

The Blue Point Reservoir site is located on Piru Creek in Secs. 3, 4, 9 and 10, T. 5 N., R. 18 W., S. B. B. and M. in Ventura and Los Angeles counties. The dam site for the reservoir is located about 500 feet north of the south line of Sec. 10.

A topographic survey of the reservoir site was made by the State in April, 1931, and a map was drawn from this survey at a scale of one inch equals 400 feet, with a contour interval of 20 feet. The water surface areas measured from this map and the capacities of the reservoir computed from them are shown in the following table:

TABLE 29

AREAS AND CAPACITIES OF BLUE POINT RESERVOIR

Elevation of water surface, in feet[1]	Area of water surface, in acres	Capacity of reservoir, in acre-feet
1,110	0	0
1,120	2	10
1,140	28	318
1,160	65	1,254
1,180	127	3,173
1,200	180	6,244
1,220	232	10,368
1,240	279	15,476
1,260	326	21,528
1,280	377	28,562
1,300	444	36,768

[1] Subtract 45 feet to obtain U. S. G. S. elevation.

The survey of the dam site was made by the State in March, 1931, and additional data were obtained in March, 1933. A topographic map drawn from this survey on a scale of one inch equals 200 feet with a contour interval of 10 feet was used in laying out and estimating the costs of dams at the Blue Point site.

The geology of the region and the dam site has been studied by Dr. Charles P. Berkey and Paul F. Kerr, Hyde Forbes, and Chester Marliave. The dam site has been explored by trenching on both abutments and by test hole drilling. Five holes were drilled in the stream bed and four of these penetrated the stream gravels and were continued into the bedrock. One hole was bored vertically into the right abutment at an elevation about 160 feet above the stream bed. The following geological data have been taken from a report by Chester Marliave:

The region in the vicinity of the dam site is composed entirely of Tertiary sediments which are rather poorly cemented sandstones interbedded with clay shales.

The regional structure is somewhat complex, the sedimentary beds being considerably folded and in the vicinity of the dam site they are overturned. The intense folding which some of the beds have undergone has resulted in numerous sharp anticlines and synclines which are conspicuous along the canyon in certain places. Accompanying these crustal movements there has been considerable local faulting and slipping, but no major faults were observed in this locality.

In the vicinity of the dam site the sedimentary beds are in the reverse order from the way that they were laid down. The older or earlier formations now rest upon the younger or later ones. This condition is due to an overturned anticline located about a mile upstream from the site which is one of the main structural features of the folding in this vicinity.

The bedrock at the dam site shows a formational contact. The red beds of the Sespe formation merge into the light colored buff beds of the Vaqueros formation. At the contact there are several hard thin strata of calcareous sandstone about a foot in thickness that are much more resistant than the accompanying strata and act as protective layers preventing disintegration of the softer underlying beds. On account of the inclination of the beds these hard sandstone layers form projecting ridges on each side of the canyon. The softer Vaqueros sediments underlying these harder strata weather easily so that there are high vertical bluffs on their downstream side. Resting upon these hard thin sandstone strata are the red beds of the Sespe formation which are composed of alternating hard and soft layers of sandstone and shale occupying an area 700 feet upstream from the dam site. On either side of the canyon the sedimentary beds dip uniformly upstream at an angle of 50 degrees from the horizontal, while the strike is at right angles to the direction of the stream channel.

The channel section at the dam site is about 175 feet wide at the constriction of the bluffs and somewhat wider along the axis of the dam site. The drill holes put down through the gravels show that bedrock under the stream bed lies close to 90 feet below the surface. This information is on record in previous geologic reports. The material encountered in these holes where bedrock was reached is the same as that disclosed on the abutments of the dam site.

There appears to be a minor fault running along the stream bed under the dam site. This is obscured by the stream gravels, but there is evidence of its existence. The straight uniform channel of the stream for a distance of 6000 feet below the dam site is indicative of a fault, but its continuation upstream is not in evidence although the fault may merge into one of the intense folds. At the dam site the beds along the contact of the Sespe and Vaqueros formations do not closely line up across the stream bed. They appear to merge beneath the gravels with a horizontal displacement of about 25 feet, the strata on the left abutment having moved upstream with reference to the strata on the right abutment. The apparent displacement of about 25 feet might result from a bending or folding of the strata beneath the channel, but the dislocation is nevertheless evident. There is step faulting along the white strata in the bluff near the stream bed. This shows movement in the direction mentioned. If this step faulting continues below the stream bed to accumulate the displacement of 25 feet, then the bedrock is very badly fractured, but if it does not continue then there is probably quite a slip causing the displacement, and the stream has cut its channel along this line or zone of weakness.

The main portion of the left end of the dam should be confined to the small depression upstream from the prominent outcropping rib of harder rock. Two minor faults occur across this abutment within the limits of the dam site. The sediments of the left abutment dip uniformly upstream in a monoclinal structure across the site. There is a large amount of talus material scattered along the bottom of the draw over which the proposed dam would rest. All of this loose material would have to be removed before any type of dam could be built at this site.

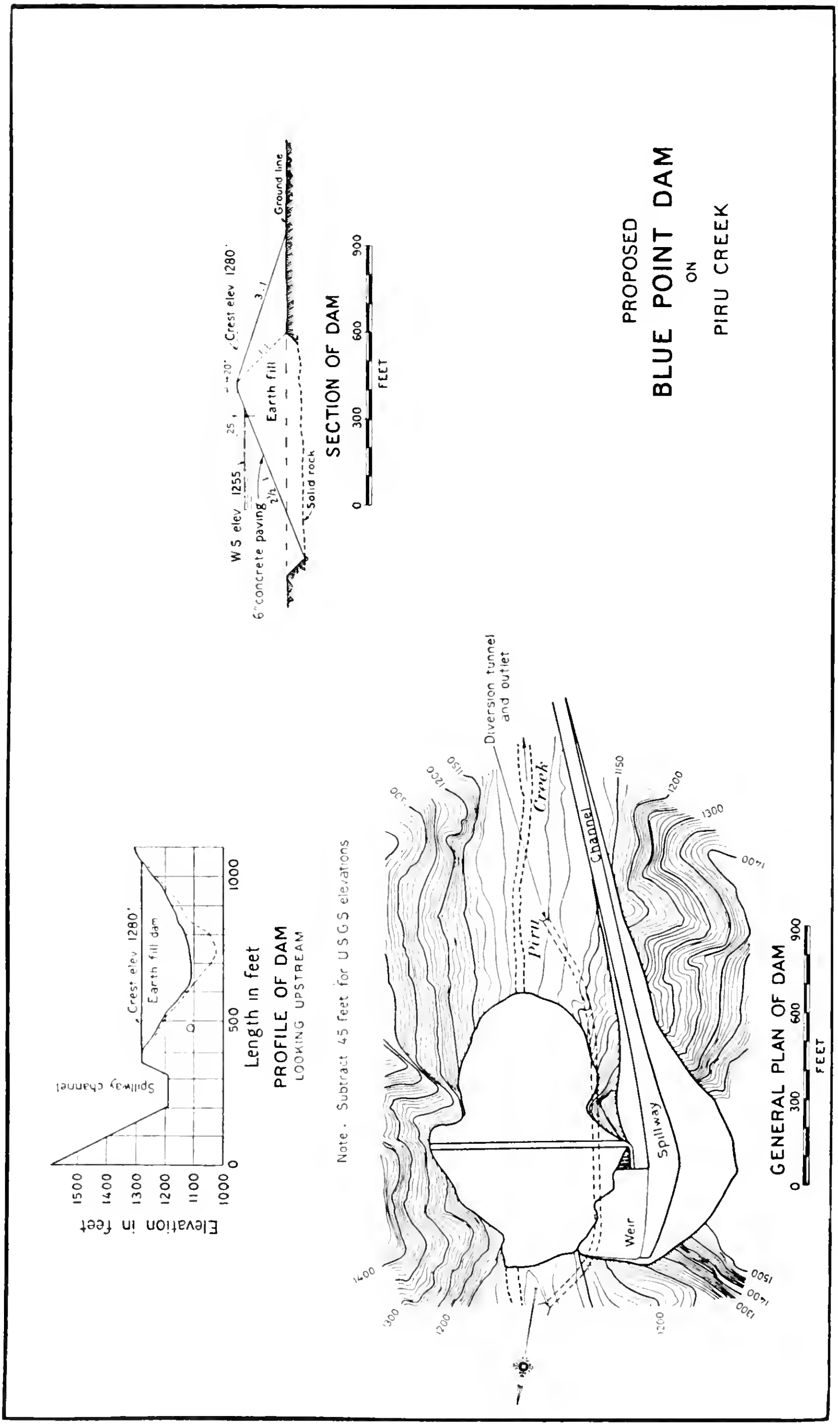
The right end of the dam should rest in the depression upstream from the prominent outcropped rib of rock on that side of the canyon. Within the immediate limits of the dam site, the structure at this abutment is monoclinal but the upper portion merges into an inclined syncline which is badly distorted and faulted. One fault traverses the abutment in a vertical direction at an elevation of about 140 feet above the stream bed and has probably crushed the bed rock to a considerable extent. There is a large amount of talus material along the lower slope of this abutment resulting from the weathering of the Sespe formation higher up on the slope of the hill.

It is believed that on account of foundation conditions, only a flexible type of dam with a broad base should be constructed at this site. No good rock for such type of dam is available in the immediate vicinity but material for an earth fill is found just below the dam site. The earth fill type was therefore selected as the most suitable for this reservoir.

Also, on account of foundation conditions, it is doubtful that a dam more than 150 to 175 feet in height would be safe. Estimates have therefore been made for the costs of reservoirs with earth fill dams 130 and 165 feet in height. Layout of a dam 165 feet in height is shown on Plate XXIX. Both of these dams would be located with the crest line or axis well into the depressions just upstream from the prominent outcropping ribs or bluffs at the site, described above. The dam would have a crest width of 20 feet, an upstream slope of 2.5:1, and a downstream slope of 3:1. It would be of the rolled fill type. All of the downstream section lying between the downstream face of the dam and a plane on a slope of 1:1 from the downstream crest line would be of pervious material obtained from the stream channel. Under this section of the dam, no material would be excavated except for the removal of loose surface material and vegetation. The remainder of the dam would be constructed of impervious material obtained from borrow pits in the vicinity of the dam and could be compacted by rolling. Under this section of the dam all loose material would be excavated to a firm rock foundation. The upstream face of the dam would be protected by a 6-inch layer of reinforced concrete terminating in a small toe wall set into the solid rock at the toe of the dam.

The spillway would be of the side channel type and would be located on the right side of the canyon with the crest just upstream from the crest of the dam. The spillway crest would be 314 feet in length and 25 feet below the top of the dam. With this length of spillway it is estimated that a flood of 98,000 second-feet, the estimated crest flow of a flood which may occur once in 1000 years on the average, will pass the dam without encroaching on the upper seven feet of the freeboard. No gates would be placed in the spillway and the normal maximum water surface would therefore be at the elevation of the spillway crest. The spillway channel would have bottom widths increasing from 30 feet at the upstream end to 109 feet opposite the downstream end of the spillway crest. It would then decrease in width as the channel follows down the slope of the canyon wall to the stream bed. The spillway crest and the channel would be lined with reinforced concrete.

PLATE XXIX


PROPOSED
BLUE POINT DAM
ON
PIRU CREEK
SECTION OF DAM
W S elev 1255
Crest elev 1280'
6" concrete paving
Earth fill
Solid rock
Ground line
0 300 600 900
FEET
PROFILE OF DAM
LOOKING UPSTREAM
Elevation in feet
Length in feet
Spillway channel
Crest elev 1280'
Earth fill dam
Note. Subtract 45 feet for U S G S elevations
GENERAL PLAN OF DAM
0 300 600 900
FEET
Diversion tunnel and outlet
Piru Creek
Channel
Spillway
Weir

The stream would be diverted during construction through a concrete lined tunnel 20 feet in diameter under the right abutment of the dam. After the completion of the dam, this tunnel would be used for the outlet from the reservoir. A concrete plug would be placed in the upstream end of the tunnel and a 60-inch steel pipe would be laid through this plug and extended through the tunnel to its downstream end. A slide gate would be placed in the pipe just downstream from the plug and a needle valve for regulating the flow would be placed at the outlet end. A trash rack structure would be constructed at the inlet of the tunnel.

Only a portion of the land in the reservoir is privately owned and the remainder belongs to the United State Government. It is therefore assumed that the only cost for the reservoir site would be for the acquisition of about 320 acres of the privately owned lands with the improvements. There are no other improvements within the reservoir site which would have to be acquired or relocated.

It is estimated from borings and surface indications that 15 to 90 feet of gravel and boulders would be removed from the stream bed under the impervious section of the dam and that 5 to 30 feet of soil and decomposed rock would be removed from the abutments under the same section. The material for the impervious section could be obtained from borrow pits located on both sides of the canyon about 1500 feet below the dam site. Gravel and sand for the concrete could be obtained from the stream bed for a distance of about one mile downstream from the dam site. The cement would be hauled by truck from the railroad at Piru.

The estimated total costs for the reservoirs with both heights of earth fill dams studied are given in the following table:

TABLE 30

COSTS OF BLUE POINT RESERVOIRS WITH EARTH FILL DAMS

Crest elevation, in feet[1]	Water surface elevation, in feet	Capacity of reservoir, in acre-feet	Capital cost	Cost per acre-foot of capacity
1,245	1,220	10,500	$3,033,800	$289
[2]1,280	1,255	20,000	3,514,000	176

[1] Subtract 45 feet to obtain U. S. G. S. elevation.
[2] A detailed cost estimate of this reservoir is given on page 233. The same items and similar unit prices were used for the lower dam.

Devil Canyon Reservoir.

Devil Canyon Reservoir site is located on Piru Creek in Secs. 3, 4, 9, 10, 14, 15, 16, 21, and 22, T. 5 N., R. 18 W., S. B. B. and M. The dam site for the reservoir is located in the south half of Sec. 22 about 300 feet north of the south line of the section.

A topographic survey of the reservoir site was made by the State in April, 1931, and a map was drawn from this survey at a scale of one inch equals 400 feet, with a contour interval of 20 feet. The water surface areas measured from this map and the capacities of the reservoir computed from them are shown in the following table:

TABLE 31

AREAS AND CAPACITIES OF DEVIL CANYON RESERVOIR

Elevation of water surface, in feet[1]	Area of water surface, in acres	Capacity of reservoir, in acre-feet
1,030	2	---
1,040	25	135
1,060	57	955
1,080	93	2,455
1,100	173	5,115
1,120	263	9,475
1,140	347	15,575
1,160	424	23,285
1,180	531	32,835
1,200	628	44,425
1,220	726	57,965
1,240	823	73,455

[1] Subtract 45 feet to obtain U. S. G. S. elevation.

A survey of the dam site was made by the State in April, 1933. A topographic map drawn from this survey on a scale of one inch equals 100 feet with a contour interval of 10 feet was used in laying out and estimating the costs of the dams at the Devil Canyon site.

The geology of the region and the dam site has been studied by Dr. Charles P. Berkey, Paul F. Kerr, Hyde Forbes and Chester Marliave. The exploration work that has been done at the dam site is sinking two test pits, drilling two test holes at the base of slope and one 150 feet up the slope on the right side of the canyon to determine the character of the foundation rock, and drilling two holes in the stream bed to determine the depth of the gravel fill and the character of the underlying rock. The following geological data have been taken from a report by Chester Marliave:

The region is one of Tertiary sediments composed for the most part of clay shales and interbedded sandstones with occasional strata of conglomerate. The area has been subjected to lateral compression in a general north and south direction with the resulting anticlinal and synclinal folds having an east and west trend. Minor faulting has accompanied some of the folding, but no breaks or dislocations have been observed passing through the dam site.

The reservoir site above the proposed Devil Canyon Dam rests entirely upon the sediments of the Modelo formation. This series of Tertiary sediments is made up of beds of diatomaceous and clay shales interbedded with sandstone and some conglomerate. The series would form a tight and impervious reservoir.

The bedrock at the dam site is also part of the Modelo series. Sandstone and shales form the two abutments and appear to be continuous under the stream gravels. Some of the strata can be projected across the canyon and identified on the opposite slopes, which indicates that there is evidently no major faulting down the canyon.

The sandstones are more resistant to weathering than are the shales and stand out more prominently on the hillsides. They are mostly coarse grained and white to buff colored on the surface, and are occasionally massive but generally alternately bedded with the shales in varying proportions. Some of the sandstone strata are quite hard and ring under the hammer, but these strata are seldom over 5 feet in

thickness. They are continuous, however, across the canyon and if they are unbroken in the stream bed would act as cut-offs to any percolating ground water. The sandstone, for the most part, is poorly cemented and some of the beds weather rather unevenly.

The shales at the dam site are mostly siliceous, with some dark colored clay partings interbedded. They weather down into small flat angular fragments along the outcrops yielding a soil which feels much like a handful of soda cracker crumbs.

The structure of the beds at the dam site selected is monoclinal but having a slight curve. It forms the south limb of an anticlinal fold that turns over just a short distance above the upstream toe of the dam site. The beds at the dam site, however, appear to be continuous from one side of the canyon to the other, dipping downstream at an average angle of 45 degrees from the horizontal. The direction of the bedding planes strikes across the canyon almost at right angles to the canyon.

The solubility of the foundation rock is not appreciable. There is very little evidence of solution leaching out the cementing material either in the sandstones or the shales, nor is there any structure in the bedrock that might be weakened by such action.

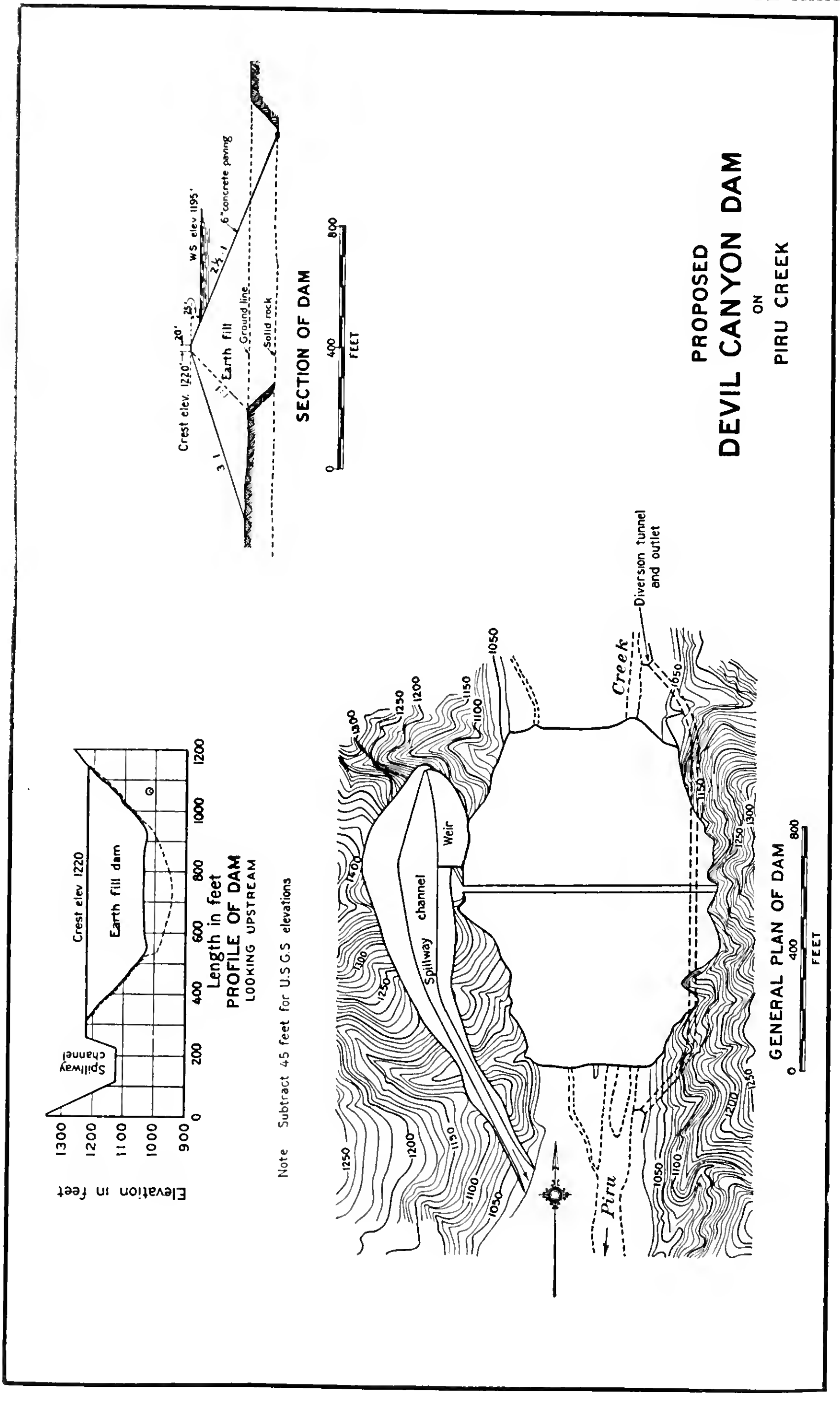
The permeability of the rock is not very great. The attitude of the beds dipping downstream would tend to seal off any water from getting through the abutments as each stratum would act as a cut-off to stop it.

The total distance of travel to get around the dam would be so great that could any seepage percolate through the formation, which is unlikely, the rate of flow would be very small. The steep attitude of the beds would force any contained water down along these planes into the bedrock where it would seal itself off from escape.

On the right abutment of the dam site, the strata are not as well exposed as on the opposite side of the canyon. However, the bedrock has been exposed nearly continuously along the bottom of the abutment at its junction with the gravel fill. The rock formation thus exposed is much the same and shows a cross section of the various beds that make up the foundation rock over the whole abutment which is continuous with that under the channel and on the opposite abutment. There is one ravine that has been eroded down the face of this abutment, but examination shows that it is only an erosional feature and discloses no structural break. On the downstream side of the ridge forming the right abutment there is a fault contact. This is an inactive fault, sufficiently far removed from the end of the proposed dam not to affect the integrity of the abutment.

On the left abutment of the dam site, the strata are inclined, with the more resistant sandstone ridges standing out in relief. The strata are not distorted and have a uniform structure. The anticlinal axis of folding runs up a canyon which is just upstream from the toe of the proposed dam. This canyon, which in general indicates the axis of flexure, was examined and shows no faulting, for the beds can be followed continuously across the canyon and down over the abutment of the dam. This character of the strata which has permitted them to bend without fracturing and faulting shows them to be favorable as

PLATE XXX



PROPOSED
DEVIL CANYON DAM
ON
PIRU CREEK
SECTION OF DAM
Crest elev. 1220'
20'
25'
WS elev 1195'
2½:1
6" concrete paving
3:1
Earth fill
Ground line
Solid rock
0
400
800
FEET
PROFILE OF DAM
LOOKING UPSTREAM
Crest elev 1220
Earth fill dam
Spillway channel
Elevation in feet
Length in feet
Note Subtract 45 feet for U.S.G.S elevations
GENERAL PLAN OF DAM
Spillway channel
Weir
Diversion tunnel and outlet
Creek
Piru

foundation rock for a dam. The even surfaced slopes along the upstream toe of the dam indicate that the shale and sandstone have weathered evenly, leaving no prominent outcropping of hard sandstone.

The channel section is about 400 feet wide and contains a gravel fill with a maximum depth of 80 to 90 feet. There is nothing in the regional geology to suggest faulting down the canyon and the structural conditions on both sides of the canyon indicate a continuity of the formations across the bottom.

It is believed that on account of the character of the foundation materials, only a broad based, flexible type dam should be constructed at this site. No rock for a rock fill dam is available within reasonable hauling distance, so all estimates made for dams at this site are based on an earth fill type. Estimates have been made for the cost of reservoirs with dams 110, 146, 185 and 215 feet in height. Layout of a 185-foot dam is shown on Plate XXX. All of these dams were located with the crest or axis line in the same position in the canyon. This position is about half way between the ravines in the right and left abutments referred to above, and 300 feet north of the south line of Sec. 22. The dam would have a crest width of 20 feet, an upstream slope of 2.5:1 and a downstream slope of 3:1. All of the downstream section lying between the downstream face and a plane on a slope of 1:1 from the downstream crest line would be of pervious material obtained from the stream channel and rolled into place. Under this section of the dam, no material would be excavated except for the removal of loose surface material and vegetation. The remainder of the dam would be constructed of impervious material obtained from borrow pits in the vicinity of the dam and compacted either by the hydraulic process or by rolling. Under this section of the dam all loose material would be excavated to a firm rock foundation. The upstream face of the dam would be protected by a 6-inch layer of reinforced concrete terminating in a small toe wall set into the solid rock at the toe of the dam.

The spillway would be of the side channel type and would be located on the right side of the canyon with the crest just upstream from the crest of the dam. The spillway crest would be 314 feet in length and 25 feet below the top of the dam. With this length of spillway it is estimated that a flood of 106,000 second-feet, the estimated crest flow of a flood which may occur once in 1000 years on the average, will pass the dam without encroaching on the upper 6.5 feet of the freeboard of the dam. No gates would be placed in the spillway and the normal maximum water surface would therefore be at the elevation of the spillway crest. The bottom of the spillway channel would vary in width from 15 feet at the upper end to 125 feet opposite the downstream end of the spillway crest. It would then decrease in width as the channel follows down the slope of the canyon wall to the stream bed. The spillway crest and the channel would be lined with reinforced concrete.

The stream would be diverted during construction through a concrete lined tunnel 20 feet in diameter under the right abutment of the dam. After the completion of the dam, this tunnel would be used for the outlet from the reservoir. A concrete plug would be placed in the upstream end of the tunnel and a 60-inch steel pipe would be laid

through this plug and extended through the tunnel to its downstream end. A slide gate would be placed in this pipe just downstream from the plug and a needle valve for regulating the flow would be placed at the outlet end. A trash rack structure would be constructed at the inlet of the tunnel.

Only a portion of the land in the reservoir is privately owned and the remainder belongs to the United States Government. It is therefore assumed that the only cost for reservoir lands would be for the acquisition of about 650 acres of the privately owned lands. The only improvements within the reservoir are those on the lands which would be acquired and they would not have to be relocated.

It is estimated from the borings and from surface indications that 10 to 90 feet of gravel and boulders would be removed from the stream bed under the impervious section of the dam and that 5 to 20 feet of soil and decomposed rock would be removed from the abutments under the same section. The material for the impervious section could be obtained from borrow pits located on the left side of the canyon about 1500 to 2000 feet downstream from the center line of the dam. Gravel and sand for concrete could be obtained from the stream bed a short distance below the dam site. The cement would be hauled by truck from the railroad at Piru.

The estimated total costs for the reservoirs with all heights of earth fill dams studied are given in the following table:

TABLE 32

COSTS OF DEVIL CANYON RESERVOIRS WITH EARTH FILL DAMS

Crest elevation, in feet[1]	Water surface elevation, in feet	Capacity of reservoir, in acre-feet	Capital cost	Cost per acre-foot of capacity
1,145	1,120	9,400	$2,705,800	$288
1,181	1,156	21,500	3,321,800	155
[2]1,220	1,195	41,300	3,991,100	97
1,250	1,225	61,500	4,738,700	77

[1] Subtract 45 feet to obtain U. S. G. S. elevation.
[2] A detailed cost estimate of this reservoir is given on page 234. The same items and similar unit prices were used for the other dams.

Cold Spring Reservoir

Cold Spring Reservoir site is located on Sespe Creek in Sec. 6, T. 5 N., R. 22 W., S. B. B. and M.; Secs. 1, 2 and 3, T. 5 N., R. 23 W., S. B. B. and M.; and Secs. 31 and 32 in T. 6 N., R. 22 W., S. B. B. and M., in Ventura County. The dam site for the reservoir is located in lots 8 and 9 of Sec. 6, T. 5 N., R. 22 W., S. B. B. and M., about one-half mile upstream from the mouth of Howard Creek. A topographic survey of the reservoir site was made by the engineering offices of J. B. Lippincott in July, 1925, and a map was drawn from this survey at a scale of about one inch equals 600 feet with a contour interval of 10 feet. The water surface areas measured from this map and the capacities of the reservoir computed from them are shown in the following table:

TABLE 33

AREAS AND CAPACITIES OF COLD SPRING RESERVOIR

Elevation of water surface, in feet	Area of water surface, in acres	Capacity of reservoir, in acre-feet
3,210	0	0
3,220	2	10
3,230	10	70
3,240	22	230
3,250	35	515
3,260	55	965
3,270	70	1,590
3,280	95	2,415
3,290	125	3,515
3,300	158	4,930
3,310	196	6,700
3,320	226	8,810
3,330	256	11,220
3.340	292	13,960
3,350	350	17,170
3,360	412	20,980
3,370	480	25,440
3,380	550	30,590
3,390	620	36,440
3,400	690	42,990
3,410	762	50,250
3,420	843	58,275

A survey of the dam site was also made by the engineering offices of J. B. Lippincott. A topographic map drawn from this survey at a scale of one inch equals 100 feet, with a contour interval of 10 feet, was used in laying out and estimating the costs of dams at the Cold Spring site.

The geology of the dam site has been studied by Dr. Charles P. Berkey and Paul F. Kerr, and Hyde Forbes. No exploratory work of any kind has been done at the dam site. The following geological data on the dam site have been taken from the report by Dr. Berkey and Paul F. Kerr:

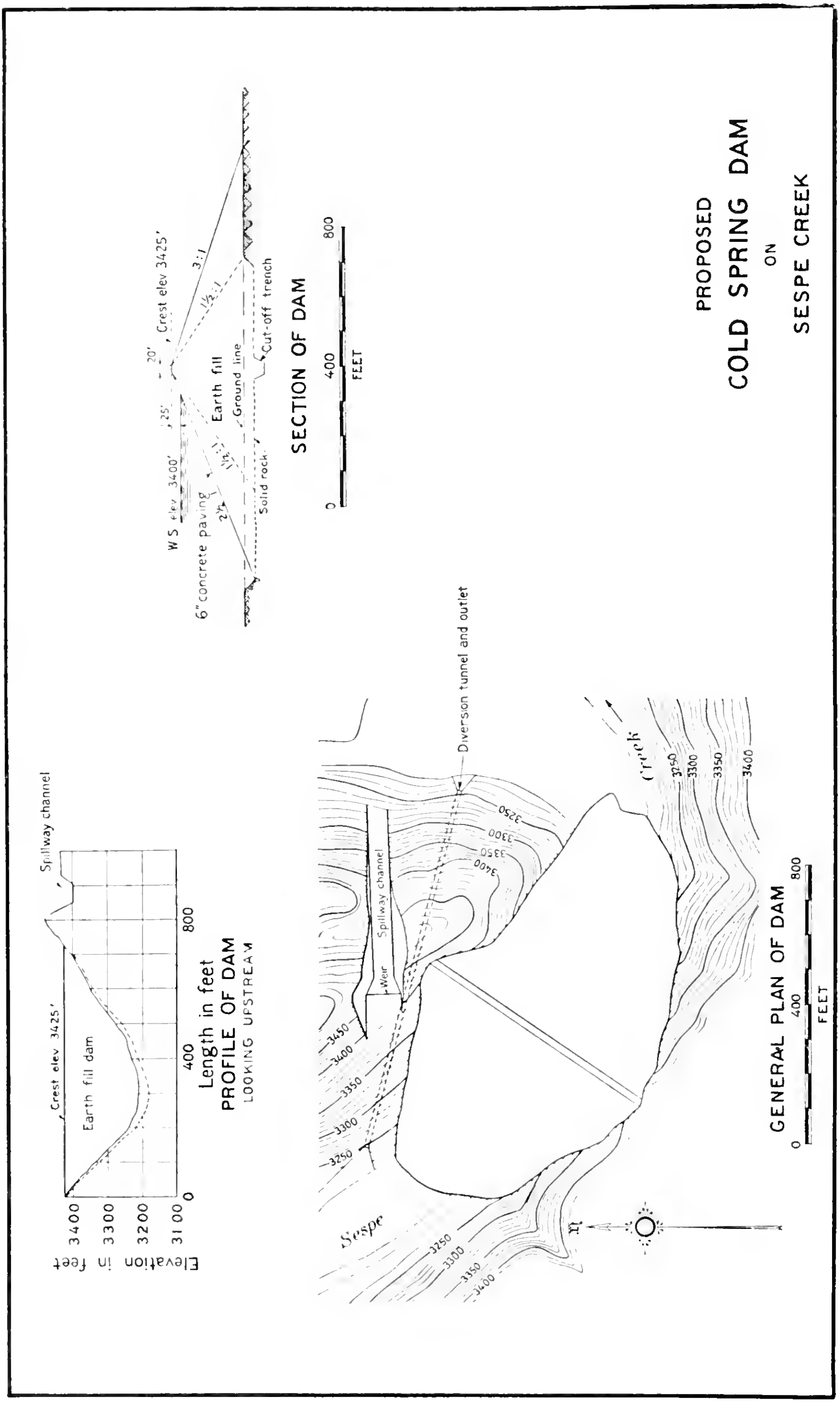
The proposed site is located in an area of moderately inclined sandy shales and sandstone of Eocene age. The strata lie nearly flat at the best location, being only slightly arched so that the angle of dip is not more than 8 degrees from the horizontal.

Several resistant sandstone beds are exposed on the canyon walls on either side of the proposed dam site. One of these beds outcrops along the north canyon wall and continues for several hundred yards on either side of the proposed dam site. It is a bed of approximately 25 feet in thickness, and is made up of hard, massive sandstone. The bed is almost flat-lying, but at a point upstream from the dam site a dip of approximately 8 degrees was observed. Lower on the north hillside are other sandstone members, some of which are decidedly lenticular, and can not be traced for any great distance on either side of the dam site. Between the sandstone members are considerable thicknesses of sandy shale agreeing in attitude with the strike and dip of the sandstone members.

The conditions in the south wall of the canyon are similar in many respects to those just described for the north wall. Prominent sandstone beds are also exposed with intervening shale. The beds on the south side of the canyon, however, do not appear to match the beds

10—8367—8375

PLATE XXXI


PROPOSED
COLD SPRING DAM
ON
SESPE CREEK
SECTION OF DAM
W S elev 3400'
25'
20'
Crest elev 3425'
3:1
$1\frac{1}{2}$:1
Earth fill
Ground line
Cut-off trench
Solid rock
6" concrete paving
$2\frac{1}{2}$:1
0
400
800
FEET
PROFILE OF DAM
LOOKING UPSTREAM
Spillway channel
Crest elev 3425'
Earth fill dam
Elevation in feet
3400
3300
3200
3100
Length in feet
GENERAL PLAN OF DAM
Diversion tunnel and outlet
Spillway channel
Weir
Sespe
Creek
3250
3300
3350
3400
3450

in the north canyon wall. This situation seems to be due to the lenticular habit of the individual beds of this formation. It is probable that the beds on the north side gradually thin down and virtually disappear before reaching the south canyon wall. Similarly, some of the beds of the south canyon wall seem to disappear before reaching the opposite side of the canyon. The result of this lenticularity is an apparent discrepancy in the strata of the two sides of the canyon. This normally suggests displacement. Continuation of some of the beds around the bend below the dam site, however, shows that the discrepancy is entirely due to original sedimentation instead of to faulting.

On account of the location of the site, the character of the foundation rock, and the materials for dam construction available in the vicinity, the only type of dam for which estimates were made is the earth fill. Estimates have been made of the costs of reservoirs with dams 145, 175 and 215 feet in height. Layout of a 215-foot dam is shown on Plate XXXI. All of these dams would be located in approximately the same position in the canyon, which is just above a 90-degree bend in the stream and just west of the east line of Sec. 6. Each dam would be located so that the downstream toe would lie just above the bend in the stream. The dam would have a crest width of 20 feet, an upstream slope of 2.5:1, and a downstream slope of 3:1. The central portion of the dam lying between planes on slopes of 1.5:1 upstream and downstream from the upstream and downstream crest lines, respectively, would be placed wet by the hydraulic process. The remainder of the material in the dam would be placed dry and compacted by rolling. A cut-off trench about 30 feet deep and 30 feet in width would be excavated on approximately the center line of the dam, across the entire canyon, and back-filled with wet material during the construction of the dam. All gravel and loose material in the stream bed and loose and decomposed material on the two abutments would be removed under the upstream rolled section and the central section of the dam placed by the hydraulic method. The upstream face of the dam would be protected by a six-inch layer of reinforced concrete terminating in a small toe wall set into the solid rock at the toe of the dam.

The spillway would be an open cut channel through the ridge which forms the left abutment of the dam. The weir at the inlet to this channel would be at right angles to the center line of the channel and would be 100 feet in length. The crest of the weir would be 25 feet below the top of the dam. This spillway channel would have a capacity of 23,500 second-feet, the crest flow of a flood which may occur once in 1000 years on the average, with a net freeboard of over 6 feet on the dam. The channel would narrow from a 100-foot bottom width at the weir to 60 feet at a distance of about 50 feet from the weir and would continue with this width through the ridge. The water would then spill down the side of the canyon into the creek bed some distance below the dam. The spillway weir and the channel would be lined with reinforced concrete.

The stream would be diverted during construction through a concrete lined tunnel 12 feet in diameter under the left abutment of the dam. The inlet and outlet to this tunnel would be in concrete lined

open cuts. After the completion of the dam, this tunnel would be used for the outlet from the reservoir. A concrete plug would be placed in the upstream end of the tunnel and a 60-inch steel pipe would be laid through this plug and extended through the tunnel to its downstream end. A slide gate would be placed in this pipe just below the plug and a needle valve, for regulating the flow, would be placed at the outlet end. A trash rack structure would be constructed at the inlet of the tunnel.

Most of the land in the reservoir site is owned by the United States Government and it is assumed that there would be no cost for the acquisition of these lands. There are, however, four privately owned parcels aggregating about 360 acres which would have to be purchased. The only improvements within the reservoir are a few buildings on these privately owned lands and these would be acquired with the land.

It has been estimated that 10 to 30 feet of gravel and earth would have to be removed from the stream bed and about 10 feet of soil and decomposed rock from the abutments, to obtain a solid rock foundation. The materials for both the pervious and impervious sections of the dam could be obtained from borrow pits in the reservoir site a short distance from the dam. Concrete aggregates would probably have to be obtained in the vicinity of Santa Paula and hauled to the site by trucks. Cement would be hauled from the railroad at Ojai.

The estimated total costs for the reservoirs with all heights of dams studied are given in the following table:

TABLE 34

COSTS OF COLD SPRING RESERVOIRS WITH EARTH FILL DAMS

Crest elevation, in feet	Water surface elevation, in feet	Capacity of reservoir, in acre-feet	Capital cost	Cost per acre-foot of capacity
3,355	3,330	11,220	$1,503,000	$134
3,385	3,360	20,980	1,642,400	78
[1] 3,425	3,400	42,990	1,979,200	46

[1] A detailed cost estimate of this reservoir site is given on page 235. The same items and similar unit prices were used for the other dams.

Topa Topa Reservoir

Topa Topa Reservoir site is located on Sespe Creek in Secs. 26, 27, 32, 33, 34, 35 and 36, T. 6 N., R. 20 W., S. B. B. and M., in Ventura County. The dam site for the reservoir is located in the SW¼ of Sec. 36. A topographic survey of the reservoir site was made by the Fairchild Aerial Survey, Incorporated, for the State in December, 1932, and a map was drawn from this survey at a scale of one inch equals 400 feet with a contour interval of 20 feet. The water surface areas measured from this map and the capacities of the reservoir computed from them are shown in Table 35.

The survey of the dam site was made by the Santa Clara Conservation District in May, 1932. A topographic map drawn from this survey on a scale of one inch equals 100 feet with a contour interval of 10 feet was used in laying out and estimating the costs of the dams at the Topa Topa site.

TABLE 35

AREAS AND CAPACITIES OF TOPA TOPA RESERVOIR

Elevation of water surface, in feet[1]	Area of water surface, in acres	Capacity of reservoir, in acre-feet
2,090	1	
2,100	7	40
2,120	14	250
2,140	33	720
2,160	53	1,580
2,180	76	2,870
2,200	99	4,620
2,220	125	6,860
2,240	168	9,790
2,260	214	13,610
2,280	256	18,310
2,300	293	23,800
2,320	351	30,240
2,340	415	37,900
2,360	470	46,750
2,380	533	56,780
2,400	618	68,290

[1] Add 56 feet to obtain U. S. G. S. elevation.

The geology of the dam site has been studied by Dr. Charles P. Berkey and Paul F. Kerr, and Hyde Forbes. No exploratory work of any kind has been done at the dam site. The following geological data have been taken from the report by Dr. Berkey and Paul F. Kerr:

The formations at the Topa Topa location are of Eocene age, and probably belong to what is known as the Matilija sandstone member of the Tejon formation. The strata forming the floor and walls of the canyon at the dam site consist of beds of a hard, massive, greenish, mottled sandstone. The individual beds vary in thickness from a few inches to over 50 feet. Some are very uniform and massive and strongly resistant to erosion. The inclination of the strata is approximately 12 degrees, and the dip, which is remarkably uniform in the immediate vicinity of the dam site, is downstream.

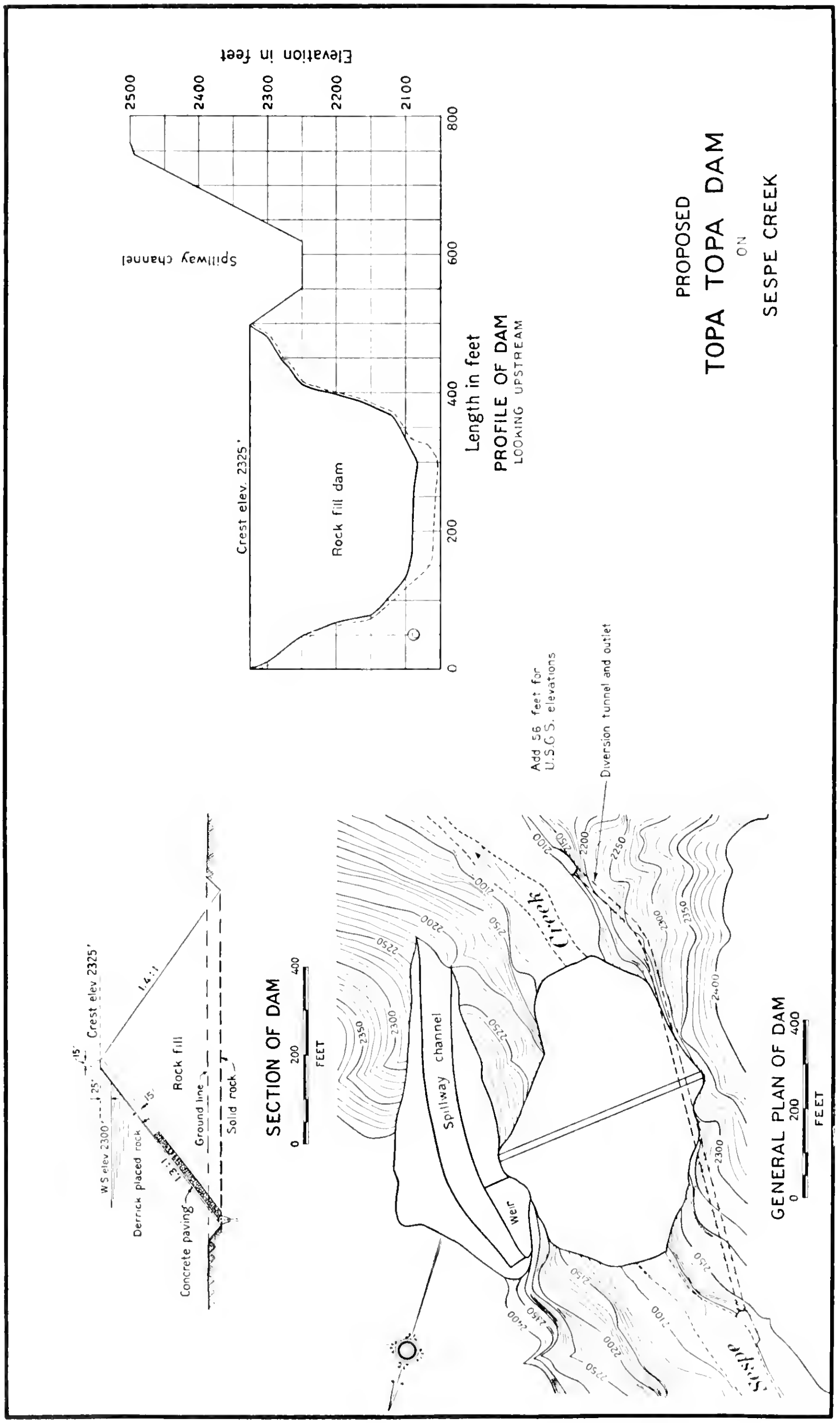
Between the large massive sandstone beds there are occasional thin beds of sandy shale. These vary from 2 or 3 inches to a foot or more in thickness, and do not resist erosion as well as the associated massive sandstones. The sandstones are prominently jointed, and frost action has pried off many blocks, the detrital material going to make up talus accumulations that obstruct the gorge. The individual blocks vary from a few inches in thickness to some that are 20, 30, or even 50 feet across.

Although there has been enough deformation to develop a considerable amount of jointing, little displacement has been recorded. Occasional displacements of from 1 to 6 inches were observed. There is virtually no gouge clay in the seams or joints, and all could be filled by grouting.

The sandstones forming the foundation and the abutments are very substantial rocks. The beds are hard and resist weathering well, as is shown by the cross profile of the gorge. The walls of the canyon at the proposed dam site rise abruptly for almost 300 feet. The canyon at the bottom is approximately 250 feet wide.

There is only indirect evidence concerning the depth of cover over the rock floor of the canyon bottom. Stream gravels cover most

PLATE XXXII


PROPOSED
TOPA TOPA DAM
ON
SESPE CREEK
Elevation in feet
2500
2400
2300
2200
2100
0
200
400
600
800
Length in feet
PROFILE OF DAM
LOOKING UPSTREAM
Crest elev. 2325'
Rock fill dam
Spillway channel
SECTION OF DAM
Crest elev 2325'
W.S. elev 2300
Derrick placed rock
Concrete paving
Rock fill
Ground line
Solid rock
1.4:1
1.3:1
15'
25'
0
200
400
FEET
GENERAL PLAN OF DAM
0
200
400
FEET
Add 56 feet for
U.S.G.S. elevations
Diversion tunnel and outlet
Spillway channel
Weir
Creek
Sespe
2100
2150
2200
2250
2300
2350
2400

of the floor, but in a few places ledges are exposed for almost half of the distance across the gorge. The out-cropping of these ledges would seem to indicate comparatively shallow cover. In no place, however, is ledge rock exposed for the entire distance across the bottom of the canyon. There is always a clogged or buried deeper gorge, but it may not be more than 25 or 30 feet deep.

There are many joints. The principal ones are almost vertical, and strike across the canyon almost at right angles to the general course of the stream. In places there are closely spaced groups of joints, probably corresponding to zones of shear.

There are no abnormal or special peculiarities, however, about these deformational structures. They are ordinary features to be expected in any region of moderate tilting.

There is no fault in the gorge at this site. It is judged that the foundation is sound and sufficiently substantial to support any type of dam.

On account of its remoteness from a railroad and the fact that no suitable concrete aggregates for a gravity concrete dam or earth for an earth fill dam are available in the vicinity, a rock fill dam is the only type which was considered for this site. Estimates have been made of the costs of reservoirs with dams 180, 240 and 300 feet in height. Layout of a 240-foot dam is shown on Plate XXXII. All of these dams were located with the center line of the crest in the same position in the canyon. The dam would have a crest width of 15 feet, an upstream slope of 1.3:1, and a downstream slope of 1.4:1. The entire section would be built up of rock dumped in place, with the exception of a layer 15 feet in thickness over the entire upstream face which would be constructed of large derrick placed rocks. The upstream face of the dam would be covered with a concrete facing with a heavy concrete cut-off wall along the toe of the dam, constructed into bedrock. Below this cut-off wall, the foundation rock would be sealed by pressure grouting. The concrete facing would consist of a subslab 12 inches in thickness at the top and increasing one inch in thickness in each 25-foot depth of dam. Over this subslab there would be a laminated reinforced concrete facing composed of slabs 6 inches in thickness. There would be two of these slabs for the first 75-foot depth of dam, and one more slab would be added in each additional 75 feet of depth.

The spillway for all heights of dam would be of the side channel type. For the highest dam it would be located on the right side of the canyon and for the two lower dams on the left side of the canyon. The spillway crest would be immediately upstream from the crest of the dam, 180 feet in length, and 25 feet below the top of the dam. The spillway would pass floods of 53,000 second-feet, the estimated crest flow of a flood which may occur once in 1000 years on the average, without encroaching on the upper 8 feet of freeboard of the dam. No gates would be placed in the spillway and the normal maximum water surface would, therefore, be at the elevation of the spillway crest. The spillway channel would have widths increasing from 40 feet at the upstream end to 70 feet opposite the downstream end of the crest and would continue with this width to the stream channel. The spillway crest and channel would be lined with reinforced concrete.

The stream would be diverted during construction through a concrete lined tunnel 15 feet in diameter under the right abutment of the dam. There would be concrete lined open cuts at the inlet and outlet ends of this tunnel. After the completion of the dam, this tunnel would be used for the outlet from the reservoir. A concrete plug would be placed in the upstream end of the tunnel and a 60-inch steel pipe would be laid through this plug and extended through the tunnel to its downstream end. A slide gate would be placed in this pipe just below the plug and a needle valve, for regulating the flow, would be placed at the outlet end. A trash rack structure would be constructed at the inlet end of the tunnel.

All of the land in the reservoir, except one small parcel, is owned by the United States Government. It is therefore assumed that the only expense for the acquisition of reservoir lands would be for the purchase of this one 80-acre tract. There are no improvements within the reservoir site which would either have to be purchased or relocated.

The dam site is at present inaccessible by road and it would therefore be necessary to build about 10½ miles of new road for the transportation of materials. The rock for the construction of the dam would be obtained from the spillway excavation or from quarries adjacent to the dam. Concrete aggregates and cement would be hauled by truck from Fillmore. It is estimated that 10 to 30 feet of gravel and loose material would be removed from the stream bed and 5 to 10 feet of loose and decomposed rock from the abutments, to obtain a solid rock foundation for the dam.

The estimated total costs for the reservoirs with all heights of dams studied are given in the following table:

TABLE 36

COSTS OF TOPA TOPA RESERVOIRS WITH ROCKFILL DAMS

Crest elevation, in feet[1]	Water surface elevation, in feet[1]	Capacity of reservoir, in acre-feet	Capital cost	Cost per acre-foot of capacity
2,265	2,240	9,790	$3,011,140	$308
[2]2,325	2,300	23,800	4,254,720	179
2,385	2,360	46,750	6,844,650	146

[1] Add 56 feet to obtain U. S. G. S. elevation.
[2] A detailed cost estimate of this reservoir is given on page 236. The same items and similar unit prices were used in estimates of the other dams.

Matilija Reservoir

The Matilija Reservoir site is located on Matilija Creek, a tributary of Ventura River, in Secs. 29 and 30, T. 5 N., R. 23 W., S. B. B. and M., in Ventura County. The dam site for the reservoir is located in the NW¼ of the SE¼ of Sec. 29. A topographic survey of the reservoir site was made by the engineering offices of J. B. Lippincott in February, 1926, and a map was drawn from this survey at a scale of one inch equals 400 feet with a contour interval of 20 feet. The water surface areas measured from this map and the capacities of the reservoir computed from them are shown in the following table:

TABLE 37

AREAS AND CAPACITIES OF MATILIJA RESERVOIR

Elevation of water surface, in feet, U. S. G. S. datum	Area of water surface, in acres	Capacity of reservoir, in acre-feet
970	0	0
980	1	0
1,000	5	50
1,020	10	250
1,040	32	680
1,060	54	1,480
1,080	78	2,800
1,100	98	4,600
1,120	123	6,850
1,140	150	9,550
1,160	179	12,800

A survey of the dam site was made by the State in April, 1933. A topographic map drawn from this survey on a scale one inch equals 100 feet with a contour interval of 10 feet was used in laying out and estimating the costs of the dams at the Matilija site.

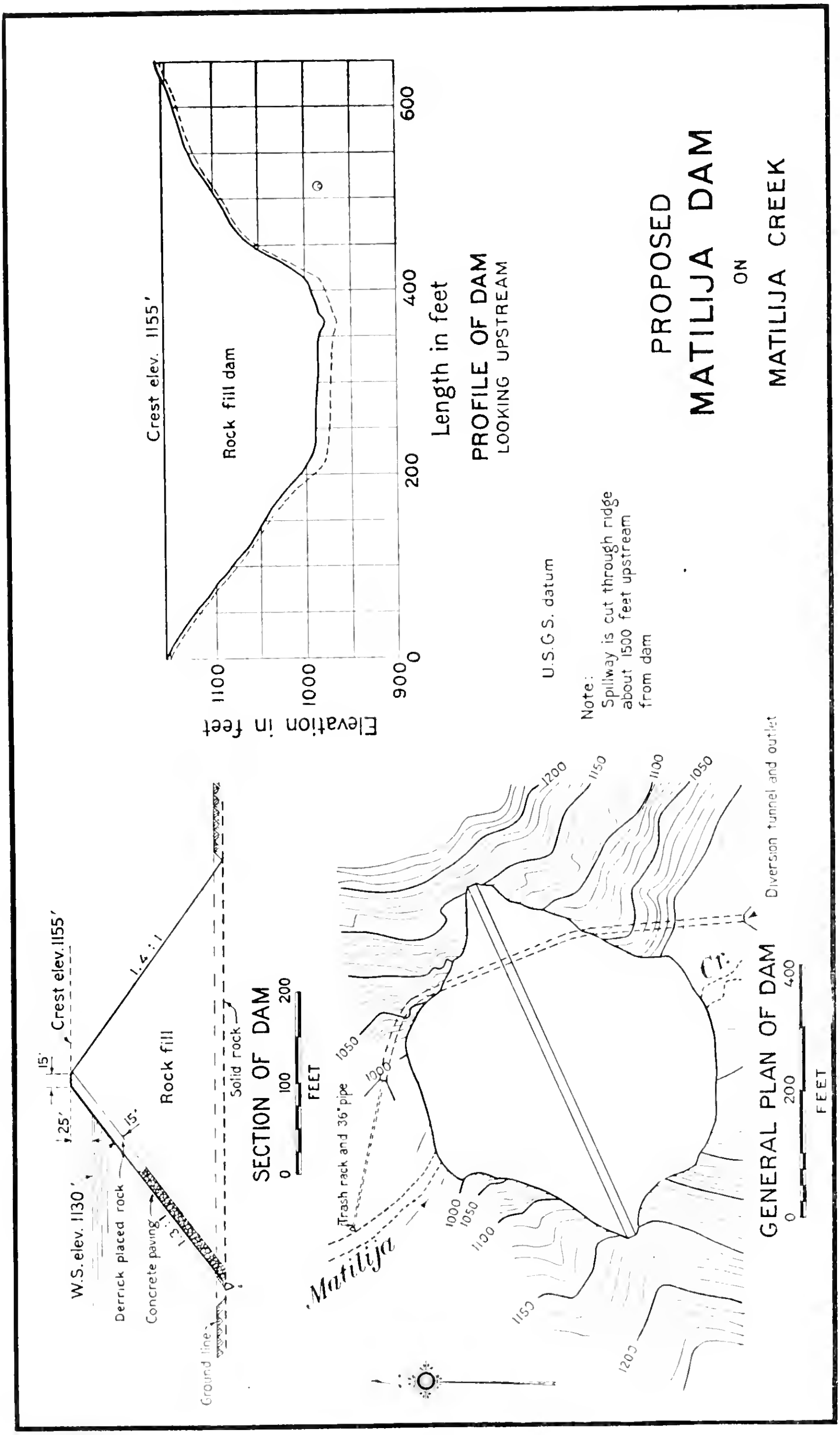
The geology of the dam site has been studied by Hyde Forbes but no exploratory work of any kind has been done. The following geological data are taken from Mr. Forbes' report:

The Matilija Dam site lies in a "V" shaped notch eroded from almost vertically dipping sandstone beds. The sandstone is of Eocene age, Tejon, which is the oldest or bottom, and most competent rock, of the Tertiary series of sediments. It is a massive, well cemented arkose sandstone, durable and resistant to weathering agencies. These massive sandstone beds dip beneath shale beds which extend upstream about a mile from the dam site, at which point Cretaceous shale beds make up the canyon walls. The overturned structure is well exposed at this point and in the shales area intervening between it and the dam site. The deformation and thrust movement within the formation has been so extensive as to produce extreme contortion and weakening of the formation as a whole. Many slickensided faces are found in the sandstone, probably the result of the massive hard sandstone beds yielding and slipping along the bedding planes and joint faces in relieving pressure exerted during the general folding. At the dam site the sandstone strikes northeast-southwest across the stream channel and dips almost vertically, the measured dips ranging from N. 75° W. 75° to N. 85° W. 70° across the stream at stream bed, flattening to 65° to 70° up the abutments. On the ridge above the west abutment, the dip is northerly about 45° and up the North Fork the same beds dip westerly about 60°.

The folding of the massive Eocene sandstone and conglomerate contrasts in a marked way with that of the thinly laminated siliceous Monterey shale found along Piru Creek. In the shale, the type of fold produced by the drag of block movement resulted in steep dipping, greatly fractured bedded structures, while the more competent sandstone beds resist deforming pressures and the folds have greater amplitude.

There is no major fault closer than two miles from the site and that approximately parallel to the axis of the dam.

PLATE XXXIII



The only type of dam considered for this location is the rock fill. Estimates have been made of the costs of reservoir with dams 135, 170 and 205 feet in height. Layout of a 170-foot dam is shown on Plate XXXIII. All of these dams were located with the center line of the crest in the same position in the canyon. The dam would have a crest width of 15 feet, an upstream slope of 1.3:1, and a downstream slope of 1.4:1. The entire section would be built up of rock dumped in place, with the exception of a layer 15 feet in thickness over the entire upstream face which would be constructed of large derrick placed rocks. The upstream face of the dam would be covered with a concrete facing with a heavy concrete cut-off wall along the toe of the dam, constructed into bedrock. Below this cut-off wall, the foundation rock would be sealed by pressure grouting. The concrete facing would consist of a subslab 12 inches in thickness at the top and increasing one inch in thickness in each 25-foot depth of dam. Over this subslab there would be a laminated reinforced concrete facing composed of slabs 6 inches in thickness. There would be two of these slabs for the first 75-foot depth of dam, and one more slab would be added in each additional 75 feet of depth.

The spillway would be an open cut through the ridge between Matilija Creek and its North Fork, about 1500 feet upstream from the dam. Material taken from this cut could be used in the construction of the dam. In addition to the cut through the ridge, some widening and deepening of the North Fork channel would be necessary. There would be a 10-foot weir 83 feet in length, with its crest 25 feet below the top of the dam, at the inlet to the spillway channel. This weir would have a capacity of 27,250 second-feet, the estimated crest flow of a flood which may occur once in 1000 years on the average, with a 5-foot net freeboard on the dam. No gates would be placed in the spillway and the normal maximum water surface would therefore be at the elevation of the crest of the weir. The channel would have a 72-foot bottom width and would be lined with reinforced concrete.

The stream would be diverted during construction through a concrete lined tunnel 10 feet in diameter under the left abutment of the dam. There would be concrete lined open cuts at the inlet and outlet of this tunnel. After completion of the dam, the tunnel would be used for the outlet from the reservoir. A concrete plug would be placed in the upper end of the tunnel and a 36-inch steel pipe would be laid through this plug and extended through the tunnel to its downstream end, and upstream from the plug to the stream channel. The portion outside of the tunnel would be laid in an open cut and encased in concrete. A slide gate would be placed in the pipe just below the tunnel plug and a needle valve, for regulating the flow, would be placed at the outlet end. A trash rack structure would be constructed at the inlet to the pipe.

All of the land in the reservoir is privately owned and it is estimated that about 300 to 400 acres would have to be acquired. There are also some buildings on these lands and these would be acquired with the land and would not have to be relocated. It is estimated that to obtain a firm rock foundation for the dam, it will be necessary to remove about 15 feet of gravel and boulders in the stream bed and 8 feet of broken and decomposed rock over the abutments. The rock for

the construction of the dam could be obtained from the spillway channel or from quarries adjacent to the dam. Aggregates for the concrete would be hauled from Santa Paula by truck, and cement would be hauled from the railroad at Ojai.

The estimated total costs for the reservoirs with all heights of dam studied are given in the following table:

TABLE 38

COST OF MATILIJA RESERVOIRS WITH ROCK FILL DAMS

Crest elevation, in feet, U. S. G. S. datum	Water surface elevation, in feet	Capacity of reservoir, in acre-feet	Capital cost	Cost per acre-foot of capacity
1,120	1,095	4,100	$2,599,000	$634
[1]1,155	1,130	8,150	2,329,000	286
1,190	1,165	13,700	3,270,000	239

[1]A detailed cost estimate of this reservoir is given on page 237. The same items and similar unit prices were used for the other dams. Cost of spillway for the lowest dam is large because for this dam the open cut through the ridge involved heavy excavation and makes the total cost of reservoir larger than for the reservoir for which detail cost estimate is given.

Camarillo Reservoir

The Camarillo Reservoir site is located on Conejo Creek in lots 39, 40, 41, 42, 43, 48 and 49 of the Rancho Calleguas, in Ventura County. The dam site for the reservoir is located in lots 39 and 40.

A topographic survey of the reservoir was made by the State in March, 1933, and a map was drawn from this survey at a scale of one inch equals 400 feet with a contour interval of 5 feet. The water surface areas measured from this map and the capacities of the reservoir computed from them are shown in the following table:

TABLE 39

AREAS AND CAPACITIES OF CAMARILLO RESERVOIR

Elevation of water surface, in feet, U. S. G. S. datum	Area of water surface, in acres	Capacity of reservoir, in acre-feet
165	4	10
170	7	36
175	27	122
180	66	357
185	118	818
190	163	1,520
195	190	2,400
200	239	3,470
205	291	4,800
210	348	6,390
215	406	8,280
220	457	10,400
225	597	12,800

The survey of the dam site was also made by the State in March, 1933. The topographic map drawn from this survey on a scale of one inch equals 100 feet with a contour interval of five feet was used in laying out and estimating the cost of the dam.

A preliminary study of the geology of the Camarillo Dam site has been made by Chester Marliave and a number of holes were bored across the dam site to determine the depth to firm foundation material. The following data on the geology have been taken from his report:

The left abutment of the dam site is agglomerate of unknown thickness containing irregular crevices through which water might pass. The right abutment of the proposed dam site is composed of terrace material probably to depths far below the footings for a dam. There may be a continuation of the agglomerate flow under the abutment but this can not be ascertained without information from test pits or drill holes. The channel section at the dam site is composed of clays and silts. Gravel appears to be absent. From the holes which have been bored through this formation it is estimated that about 15 to 50 feet of clays cover the channel section. Just below the downstream toe of the proposed dam site the agglomerate is found on both sides of the channel but there is no proof that it is continuous across the stream bed.

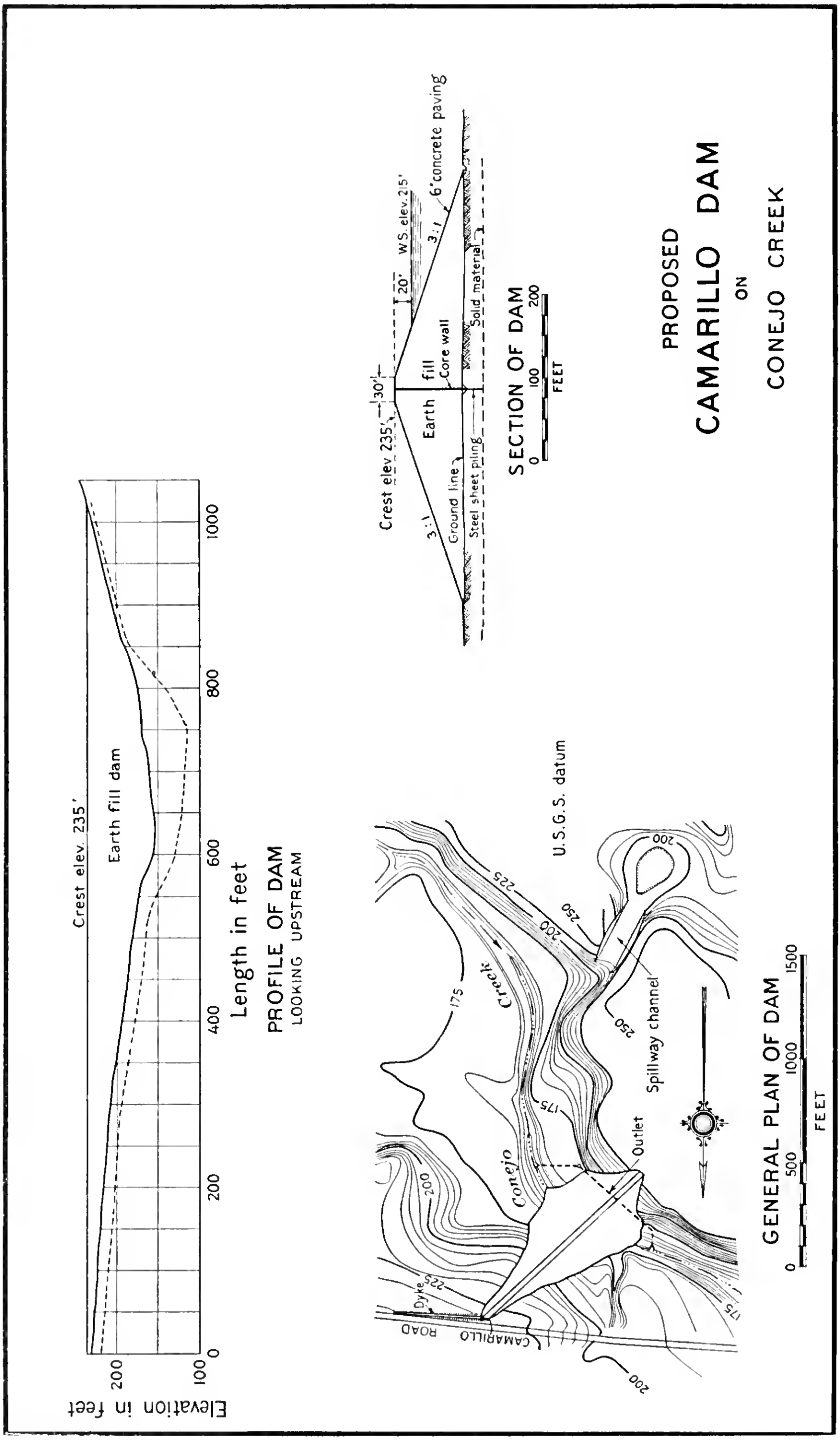
The agglomerate represents the oldest rock found at the dam site. It is a volcanic flow that rolled down the mountain from the south covering the underlying sediments to various depths depending upon their configuration at the time of the volcanic outburst. The agglomerate at the site is composed of angular volcanic rock fragments up to several feet in diameter that are cemented together with tuffs, clays, and muds, forming a rather hard homogeneous mass. The cementing materials vary in toughness. The rock weathers irregularly, leaving numerous open crevices where the cementing material is soft. The agglomerate can not be followed across the stream channel. The left side of the valley floor may represent the present edge of the flow. Three outcrops of agglomerate have been found on the right side of the stream bed at and near the dam site but these may only represent isolated patches or remnants.

The terrace deposits are composed of unconsolidated accumulations of clays, sands and gravels. These are well exposed along the road cut at the right end of the dam. They are probably absorptive to a large degree but the porous material contained therein is more or less lenticular which would decrease the rate of percolation through it.

The alluvium occupies the lower portion of the valley. It represents the residuum from the breaking down of previous formations which have been deposited by stream action and by the lateral erosion of the hillside soils. For the most part it is a sandy silt with varying amounts of clay. The alluvium on the floor of the reservoir contains considerable clay. The alluvium on the right bank of the channel just downstream from the dam site is contaminated with a sandy silt from the hillside ravine, and this material immediately sloughs down to sand when a piece of it is immersed in water.

On account of the foundation conditions, it is believed that an earth fill dam is the only suitable type for this site. Estimates were made with this type of dam for a reservoir with a capacity of 8280 acre-feet. The dam for this reservoir would be 80 feet in height, with a freeboard of 20 feet above the water surface with the foregoing reservoir capacity, or to a crest elevation of 235 feet, U. S. G. S. datum. The dam would have a crest width of 30 feet and both slopes would be 3:1. Layout is shown on Plate XXXIV. The entire dam would be constructed of earth compacted by rolling. The upstream face of the dam would be protected by a 6-inch reinforced concrete slab terminating in a small toe wall at the intersection of the upstream face with the natural ground surface. A core wall of reinforced concrete 18 inches

PLATE XXXIV


PROPOSED
CAMARILLO DAM
ON
CONEJO CREEK
PROFILE OF DAM
LOOKING UPSTREAM
Crest elev. 235'
Earth fill dam
Elevation in feet
200
100
Length in feet
0
200
400
600
800
1000
SECTION OF DAM
Crest elev 235'
30'
20'
W.S. elev. 215'
6" concrete paving
3:1
3:1
Earth fill
Core wall
Ground line
Steel sheet piling
Solid material
0 100 200
FEET
GENERAL PLAN OF DAM
U.S.G.S. datum
Conejo Creek
Spillway channel
Outlet
Dyke
CAMARILLO ROAD
175
200
225
250
0 500 1000 1500
FEET

thick would be constructed through the center of the dam. This wall would be carried through the surface material on both abutments to the firm underlying material, into which it would be keyed. For a distance of 85 feet to the right, and 185 feet to the left of the center line of the stream channel, where there is a porous alluvial fill of 15 to 50 feet, the core wall would be constructed of concrete only above the ground surface and would be extended to the firm underlying material by a row of steel sheet piling driven through the alluvium.

The spillway would be located in a saddle on the left side of the reservoir about 1000 feet upstream from the dam. The bottom of the cut through the saddle would be at elevation 215 feet, or 20 feet below the top of the dam. There would be no gates in the spillway and the normal maximum water surface would therefore be at the elevation of the spillway crest. The channel would have a bottom width of 100 feet with side slopes of 1:1. It would be lined with reinforced concrete for a distance of 280 feet from the inlet end. The spillway capacity would be 10,000 second-feet, the estimated crest flow of a flood which may occur once in 1000 years on the average, with a net freeboard of 10 feet on the dam.

The outlet from the reservoir would be placed under the left side of the dam near the base of the steep slope. It would consist of a 36-inch steel pipe encased in concrete and would be laid in an open cut excavated to firm foundation material. Water would enter the pipe through a concrete inlet tower which would be provided with two slide gates.

All of the land in the reservoir is privately owned and most of it is under cultivation. There is a county road along the right side of the reservoir, low points in which would be raised by earth fills to bring the entire road surface above the high water level of the reservoir.

Material for the earth fill for the dam would be obtained from the reservoir near the dam site. Sand and gravel for concrete would be obtained from Saticoy and hauled 14 miles by truck. Cement and other materials would be hauled five miles by truck from the railroad at Camarillo. A detailed cost estimate of the reservoir totaling $808,000 is shown on page 238.

Dunshee Reservoir

The Dunshee Reservoir site is located on Coyote Creek in the Rancho Santa Ana, in Ventura County. The dam site for the reservoir is located about five and one-half miles above the junction of Coyote Creek with the Ventura River.

A topographic survey of the reservoir site was made by E. E. Everett in August, 1931, and a map was drawn from this survey at a scale of one inch equals 200 feet with a contour interval of 10 feet. The water surface areas measured from this map and the capacities of the reservoir computed from them are shown in Table 40.

A survey of the dam site was made by E. E. Everett in August, 1933. A topographic map made from this survey on a scale of one inch equals 50 feet with a contour interval of five feet was used in laying out and estimating the costs of the dams at the Dunshee site.

TABLE 40

AREAS AND CAPACITIES OF DUNSHEE RESERVOIR

Elevation of water surface, in feet[1]	Area of water surface, in acres	Capacity of reservoir, in acre-feet
110	4	40
115	10	75
120	15	125
125	21	200
130	28	350
135	35	500
140	45	700
145	54	900
150	62	1,200
155	74	1,500
160	84	1,900
165	95	2,400
170	100	2,850
175	106	3,350
180	112	3,900
185	120	4,500
190	130	5,100
195	140	5,800
200	149	6,500
205	154	7,100
210	168	8,000
215	183	8,900
220	200	9,900

[1] Add 309.7 feet to obtain U. S. G. S. elevation.

A preliminary examination of the geology of the site has been made by Chester Marliave. The following data have been taken from his report:

The reservoir would occupy an area covered by thick deposits of gravels and clays heterogeneously mixed. It is believed that stored water would not be lost by subterranean seepage.

The vicinity of the dam site is a region of Tertiary sediments consisting of soft sandstones, clay shales and some conglomerate probably belonging to the Vaqueros, Sespe and Modelo formations. At the site the rock exposures are medium grained, fairly well cemented sandstones which alternate with clay shale beds. The sandstones occur in rather massive beds varying from several feet to 40 feet in thickness, but seldom exhibit a ring when struck with a hammer. They are somewhat fractured near the surface but tighten shortly below it. Apparently they are not crushed or distorted but in places are somewhat softened by water. The exposed shales in the trenches at the dam site are in beds varying from 1 foot to 12 feet in thickness. They do not show any appreciable amount of gypsum.

From observation of the bedding planes it is believed that there is an anticlinal fold with its axis passing down the canyon through the dam site. On the right side of the canyon the strata indicate a uniform monoclinal dip downstream but the beds of the left abutment appear to have turned over in a gentle anticlinal fold with a break occurring about 50 feet above the stream bed. For a short distance above this break there is a shelf about 100 feet wide which gives the appearance of a slide or break through this abutment.

On the right abutment of the dam site a thick hard bed of sandstone outcrops along the lower slope of the bank having an exposed thickness of about 12 feet while above it in the two trenches which

were dug on that abutment the shale beds alternate with the sandstones. These beds are uniformly tilted without evidence of folding. Upstream from the axis of the dam site there is an exposure of sandstone the attitude of which likewise shows a similar position indicating the uniformity of structure on the right abutment.

The left abutment shows a thick stratum of sandstone in the trench dug along the axis of the proposed dam. This stratum extends to a height of 50 feet above stream bed and above it occurs the break mentioned before. Above the break there are shale beds. At a point 70 feet above stream the rock surface dips and the trench exposes only an old terrace deposit of gravel and boulders.

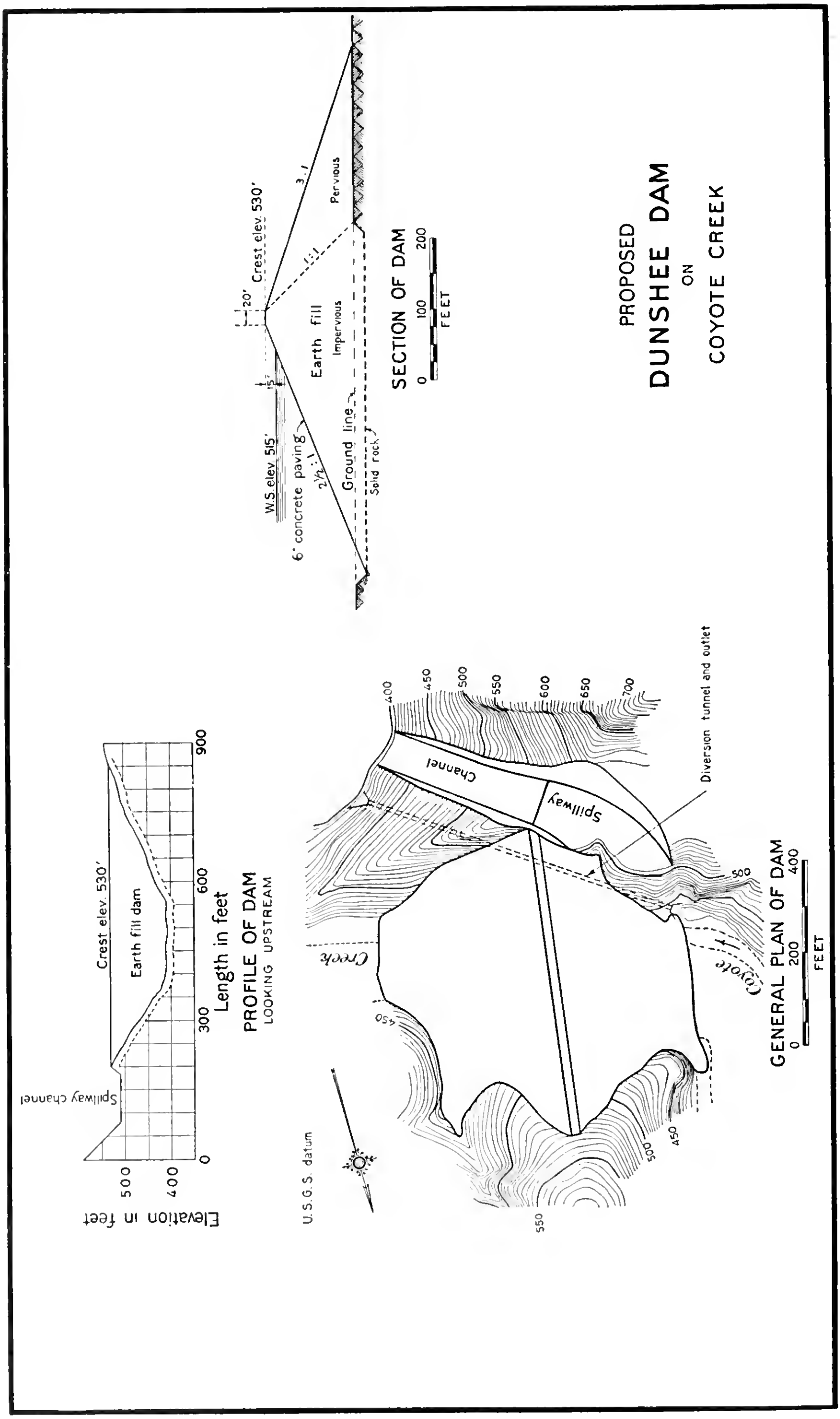
No suitable material for a rock fill dam occurs in the vicinity of the site. There is, however, ample material for an earthen dam within reasonable haul. Stripping would probably have to be done to an average normal depth of 15 feet on the sides and the stream gravels might have a maximum depth of 40 feet with an average of 20 feet across the 180-foot bottom.

The exploration work consisted of trenches on each abutment and a pit in the bottom which struck bedrock at 14 feet but it is believed that the bedrock would be found at a greater depth further from the canyon wall.

It is believed that the most suitable type of dam for this location is the earth fill. This type was therefore selected for estimating the costs of the reservoirs with dams 90, 120 and 135 feet in height. All of these dams were located with the crest or axis line in the same position in the canyon. The dam would have a crest width of 20 feet, an upstream slope of 2.5:1 and a downstream slope of 3:1. Layout of a 120-foot dam is shown on plate XXXV. All of the downstream section lying between the downstream face and a plane on a slope of 1:1 from the downstream crest line would be of pervious material. Under this section of the dam no excavation, except for the removal of loose surface material, would be made. The remainder of the dam would be constructed of impervious material compacted either by the hydraulic process or by rolling. Under this section of the dam, all loose material would be excavated to a firm rock foundation. The upstream face of the dam would be protected by a 6-inch layer of reinforced concrete terminating in a small toe wall set into the solid rock at the toe of the dam. A low dyke in a saddle about one-half mile northeast of the dam site on the left side of the reservoir would be required for all dams with a crest elevation exceeding 515 feet. The dyke would have a crest width of 20 feet, a water side slope of 2:1 and a downstream slope of 3:1. The water side face would also be protected by a 6-inch layer of reinforced concrete.

The spillway would be of the straight channel type excavated through the ridge forming the right abutment of the dam. The weir in this channel would be 100 feet in length and 15 feet below the top of the dam. The spillway could pass a flood of 9000 second-feet, the estimated crest flow of a flood which may occur once in 1000 years on the average, without the water surface in the reservoir encroaching on the upper six feet of freeboard of the dam. No gates would be placed in the spillway and the normal maximum water surface would

PLATE XXXV


PROPOSED
DUNSHEE DAM
ON
COYOTE CREEK
SECTION OF DAM
FEET
0 100 200
Crest elev. 530'
20'
15'
W.S. elev. 515'
6' concrete paving
2½:1
3:1
1:1
Earth fill
Impervious
Pervious
Ground line
Solid rock
GENERAL PLAN OF DAM
FEET
0 200 400
Channel
Spillway
Diversion tunnel and outlet
Creek
Coyote
U.S.G.S. datum
PROFILE OF DAM
LOOKING UPSTREAM
Length in feet
Elevation in feet
Crest elev. 530'
Earth fill dam
Spillway channel
0 300 600 900
400 500

therefore be at the elevation of the spillway crest. The spillway channel would extend to the creek channel at a point several hundred feet below the dam. The spillway channel would be lined with reinforced concrete.

The stream would be diverted during construction through a concrete lined tunnel 10 feet in diameter extending through the ridge at the right abutment of the dam. It also would discharge into the creek channel several hundred feet below the dam. After the completion of the dam, this tunnel would be used for the outlet from the reservoir. A concrete plug would be placed in the upstream end of the tunnel and a 36-inch steel pipe would be laid through this plug and extended through the tunnel to its downstream end. A slide gate would be placed in this pipe just downstream from the plug and a needle valve, for regulating the flow, would be placed at the outlet end. A trash rack structure would be constructed at the inlet of the tunnel.

Materials for the earth fill section would be obtained from borrow pits in the vicinity of the dam. Gravel and sand for the concrete would have to be obtained from an outside source and it has been assumed in making the estimates that these materials would be hauled from Santa Paula by truck. The cement would be hauled by truck from the railroad at a point about four and one-half miles from the dam site.

The estimated total costs for the reservoirs with all heights of dam studied are given in the following table:

TABLE 41

COSTS OF DUNSHEE RESERVOIRS WITH EARTH FILL DAMS

Crest elevation, in feet, U.S.G.S. datum	Water surface elevation, in feet	Capacity of reservoir, in acre-feet	Capital cost[1]	Cost per acre-foot of capacity
500	485	3,300	$493,000	$149
[1]530	515	7,100	715,000	101
545	530	10,000	981,000	98

[1]A detailed cost estimate of this reservoir is given on page 239. The same items and similar unit costs were used for the other heights of dams.

Santa Ana Creek Diversion to Dunshee Reservoir—Water from Santa Ana Creek which enters Coyote Creek below Dunshee dam site may be diverted over a low divide into the reservoir site. A low diversion dam only would be required whence an unlined conduit of 200 second-feet capacity 1¼ miles in length would convey the water to a spillway into the reservoir. The total cost of this diversion is estimated at $35,000 and the detail is given on page 239.

CHAPTER XII

SPREADING WORKS

As previously stated the water supplies of Ventura County are made available largely by percolation of streams crossing the porous detrital fills of the valleys. This same condition obtains over southern California in general, in the valleys of the Coastal Range south of San Francisco and in San Joaquin Valley. Other things being equal the amount of recharge of the underground reservoir depends on the area covered by the stream. Efforts have been made to increase this area on various streams in southern California by means of what are termed "spreading works." In some cases structures have been placed in the stream bed to prevent channeling and to spread the water in as thin a sheet as possible. In other cases the water is diverted from the stream and caused to flow under control over unoccupied land so that it will remain in small channels, or is ponded and caused to cascade over a series of barriers. These works have been constructed near the debouchures of the streams from the mountain canyons on the coarse debris cones formed by the streams.

Until recently attempt has been made to divert only small amounts of water and then only after floods had subsided. There are two reasons why the earlier works made no attempt to divert at flood times; the first is that generally the stream is silt laden during floods and the water percolating in the offstream spreading area leaves its silt burden and seals the surface so that percolation ceases; the second is that adequate diversion works had not been constructed.

Offstream spreading works have been successfully operated by Santa Clara Conservation District near Piru diverting from Piru Creek and in the Montalvo area of the Coastal Plain diverting from Santa Clara River. Capacities are 80 second-feet and 45 second-feet, respectively. No attempt is made to divert during floods nor until the silt content has dropped to some predetermined percentage. Permanent diversion works have not been installed.

In recent years funds have become available which have enabled planning of offstream spreading works on a large scale and such works are now being installed in San Bernardino County. The location must have two characteristics. It must be at a place where the water table is sufficiently below the surface to give considerable unoccupied capacity in the voids of the valley fill, i. e., there must be reservoir capacity and it also must be at a place where the soil material is porous, i. e., composed of gravel or sand.

The works themselves must be able to function when the water in the stream is silty and during the severe floods characteristic of southern California. In other words permanent masonry diversion works are required and also provision for desilting the water after

diversion from the stream and before discharging it to the areas where it is expected to percolate. The obvious method of desilting is by settling basins but in some cases it can be done in other ways. If by basins there must be provided methods of eventually getting rid of the silt which has settled in the pools. There must also be provided numerous roads for transportation during periods of operation.

Three spreading works were planned during the present investigation and estimates of cost and of salvage of water possible through their operation were made. These works would be:

1. In Santa Clara Valley east of the town of Piru with diversion from Piru Creek. See frontispiece and Plate XXXVII. In 1931 at lowest depth, the water table was 150 feet below the surface at the maximum point. Measured rate of percolation on the spreading works of the district further west are reported at 4.5 feet in depth of water per day.

2. In the Montalvo area of the Coastal Plain southeast of the town of Saticoy. See frontispiece and Plate XXXVIII. In 1931 at lowest depth, the water table was 80 feet below the surface at maximum point. Measured rate of percolation on spreading works of the district is reported at 7.4 feet in depth of water per day.

3. On upper Ventura River in Ventura River Valley. See frontispiece and Plate XXXIX. Little is known as to depths to water table or unit rate of percolation. The stream bed is absorptive.

On Plate XXXVI is shown the position of water table at the Piru and Montalvo locations.

Spreading works could also be installed on the stream cones northeast of the city of Ojai but no plans have been prepared. In the future if the water table lowers it may be possible to spread on Sespe Creek Cone.

TABLE 42

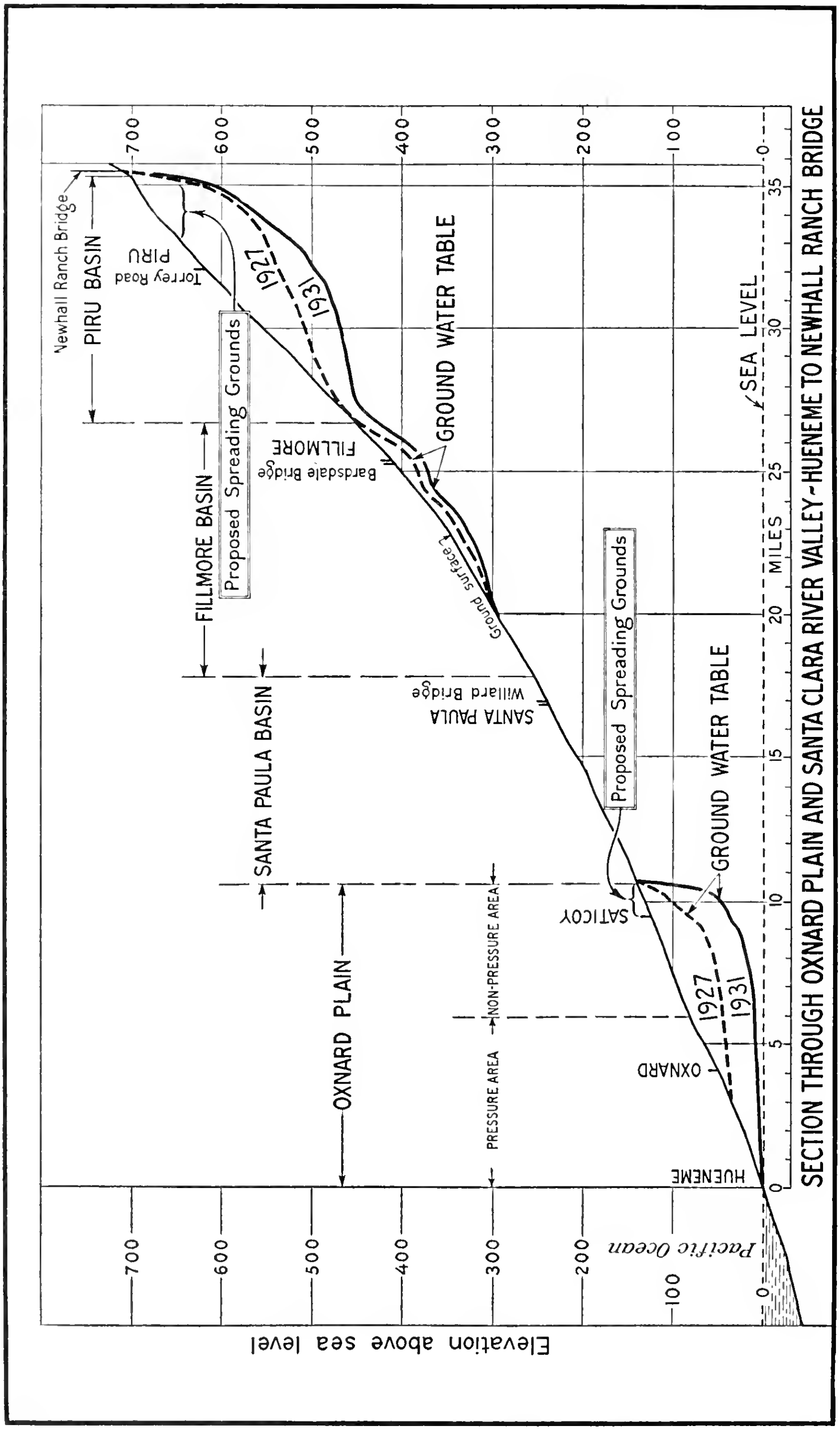
SPREADING WORKS—ESTIMATED COST AND ANNUAL SALVAGE

Basin	Diversion capacity	Average salvage, 1922–32	Cost[1]	
	Second-feet	Acre-feet	Total	Per acre-foot, salvage
Santa Clara Valley—				
Piru Basin	300	4,800	$401,000	$84
Montalvo Basin	400	12,600	348,000	28
Ventura River Valley	400	------------	142,000	------------

[1] Detail of estimated costs are given on pages 223 to 226.

The estimate of amount of water conserved by the works on Piru Basin is based on operating the works at full capacity on all days when the water would not all percolate naturally in the stream bed. In Montalvo Basin it is based on not operating an average of 6.5 days per year during floods. This average is the result of study of each individual year and in some years the number of days in which no operation would be attempted is assumed to be much greater. It is assumed that the works in Ventura Basin would be operated only at those times when water would reach the lower half of the spreading works practically desilted.

PLATE XXXVI


SECTION THROUGH OXNARD PLAIN AND SANTA CLARA RIVER VALLEY-HUENEME TO NEWHALL RANCH BRIDGE
Elevation above sea level
MILES
SEA LEVEL
Pacific Ocean
HUENEME
OXNARD
SATICOY
SANTA PAULA
Willard Bridge
FILLMORE
Bardsdale Bridge
PIRU
Torrey Road
Newhall Ranch Bridge
OXNARD PLAIN
PRESSURE AREA
NON-PRESSURE AREA
SANTA PAULA BASIN
FILLMORE BASIN
PIRU BASIN
Proposed Spreading Grounds
Proposed Spreading Grounds
GROUND WATER TABLE
GROUND WATER TABLE
Ground surface
1927
1931
1927
1931

Apparently the most difficult problem in the operation of the proposed spreading works, particularly those in Piru and Montalvo Basins would be desilting the stilling basins. At times the streams carry large amounts of fine silt. It is assumed that the desilting can be done and the silt transported into the river bed whence it would be carried to the ocean in large floods. The methods used would probably combine mechanical and flushing operations but experience only can supply the detail of the method and experience only can determine eventual success. The difficulties could be decreased by not diverting during periods of greatest silt transportation but this would decrease the salvage.

Operating cost per acre-foot of salvage would be large because of expense of desilting.

The silt problem is present in any plan to conserve the waters of Santa Clara Valley by surface reservoirs or spreading works. The difference between the two is that there is no apparently feasible way to get rid of the silt which lodges in a surface reservoir on the stream and it will eventually silt up, with consequent destruction of the investment. In spreading works it is believed possible to finally dispose of the silt and thus keep them clear.

The estimated conservation in the foregoing table is the amount of percolation which would be induced in the dry series of years 1922–1932 in addition to the natural percolation which would occur in the basins in which the spreading works are located. In the wet series of years 1905–1918 not so much would be accomplished as Piru Basin would fill without spreading and therefore no conservation can be credited to spreading works in a wet cycle after the basin is filled although if storage space were available a considerably larger annual amount could be spread in such periods as there would be water in the streams for a longer time.

Without spreading and if draft during a wet cycle is equal to the draft in the present dry cycle, it is estimated that Montalvo Basin would not fill in the series of wet years 1905–1918 but the estimated unoccupied space during a similar period would not be sufficient, with present irrigated area, to absorb as much as the above estimated conservation.

No estimate of the conservation accomplished by the proposed Ventura River Valley works has been made. Wells are lacking in the gravel beds to determine capacity and the basin is small in area, being only about three square miles in extent. Depth to bedrock from present knowledge is only about 60 feet. The basin is about 6.5 miles long with a surface slope of 80 to 100 feet per mile so that water moves underground downstream at a comparatively rapid rate and emerges as rising water at the lower end of the basin. The water table is therefore always at the surface near the lower end and presumably rises gradually upstream but on a flatter grade than the ground surface. It is probable that if the water table were raised by spreading much above its natural position, water would drift out the lower end so rapidly that there would be little long time retention. However, if there occurred sufficient draft on the basin to lower the water table during the summer, space would be provided for the water which could be

spread. It is probable that in the wet cycle the basin would fill as full as possible without spreading.

A thorough exploration of the ground water basin by drilling is necessary before construction of the proposed Ventura River Valley works is begun. After such exploration the entire matter should be reviewed in the light of the knowledge gained.

DETAILED DESCRIPTION OF PROPOSED SPREADING WORKS

Piru Basin

A permanent diversion control is proposed which would operate in floods. The point of diversion would be two and three-quarters miles above the mouth of Piru Creek. Several possible sites for a diversion dam were investigated. Foundation material consists of conglomerate and shale and with some excavation on the right bank sufficient width could be obtained to provide for the necessary spillway capacity. Average elevation of the stream bed is 742 feet and the top of the dam as estimated would be 751 feet, nine feet above the stream bed elevation.

Diversion dam would be a gravity overflow section. Cost estimates are based on a gravity mass concrete dam faced with granite boulders.

Two radial gates each 7 feet by 16 feet would be provided near the left stream bank. These would be opened during flood to permit sand, gravel, and boulders to pass through the dam and prevent filling to the crest of the diversion weir, overflowing it and filling the settling basin at the headgate of the tunnel.

Since the material of the foundation consists partly of shale, provision is made in the estimate to pave the stream bed and banks with concrete for a distance of 50 feet below the dam and both banks upstream for a distance of 25 feet from the upstream face of the dam.

Diversion would be over a weir 70 feet long with a crest set at elevation 749 feet, two feet below the crest of the dam. The sand trap below the water would be 70 feet by 188 by 5 feet, affording approximately 200 cubic feet of settling basin capacity and would be equipped with a sluicing gate at the lower end. From the sand trap chamber the water would be carried over an 18-foot weir, with crest at elevation 747 feet, into the inlet tower of the tunnel. This inlet weir would be provided with a 5-foot by 18-foot radial gate. The inlet to the tunnel would be an 8-foot by 8-foot opening with rounded corners.

The tunnel would be a circle of 6.5 feet net diameter with reinforced concrete lining 8 inches thick. In estimating the lining an overbreak of 25 per cent was allowed.

The grade of the tunnel was fixed at 3.25 feet per 1000 feet or a slope of 0.00325. The water surface at the tunnel inlet would be elevation 749 feet and at the south end of the tunnel would be elevation 732.9. The water depth in the tunnel would be 6 feet. Capacity would be 300 second-feet.

From end of tunnel to the settling basin a 2400-foot pipe line would be installed with total fall of 39.9 feet. The size of the pipe required for delivery of 300 second-feet from south portal of tunnel to spreading ground would be 5 feet net diameter. Transition from tunnel to pipe would be through a reducer with 7-degree angle. This pipe would discharge into a concrete stilling well and since the velocity in the

pipe would be about 18 feet per second the pipe would be enlarged on a 5-degree Venturi tube discharge angle for about 18 feet before entering the stilling well.

The stilling well would be located inside the partition levee between upper and lower desilting basins. The size would be 8 feet by 8 feet inside dimensions, with 12-inch reinforced concrete walls. The end wall would be built to the top of the levee at elevation 796 feet. The east side would be elevation 790 feet and would act as a weir for measuring the quantity of water spread. To provide for carrying the water directly into the lower desilting basin, two 42-inch diameter pipes with gates would be laid from near the bottom of the stilling well, under the levee discharging into the lower basin.

The desilting basins would have earth levees with 18-foot top width and 2 to 1 side slope except that on the river side where paving would be used, the slope would be steepened to $1\frac{1}{2}$ to 1 and a 6-foot berm would be added at the top of the paved section.

A flexible mattress with width of about 15 feet would be used at the toe and above this, reinforced concrete (or gunite) paving would extend to a height of 8 feet in order to protect the river side of the basin levee. A paved levee of this type would be extended upstream for a distance of about 1200 feet above the upper basin to connect to the existing high bank on the north side of Santa Clara River.

The upper basin would have an area of 51 acres, a maximum water depth of 18 feet and a capacity of 440 acre-feet with water level at 693.

The lower basin would have an area of 57 acres, a maximum depth of 17 feet and a capacity of 520 acre-feet with water level at 682.

Freeboard of the main levees would be 3 feet.

A training levee is proposed in the upper basin to divert the incoming water to the upper end of the basin and thus cause a more uniform distribution of the silt.

The outflow from the upper basin to the lower basin would be through three overpour spillways with flashboard controlled sluices which may be used for partial drawdown.

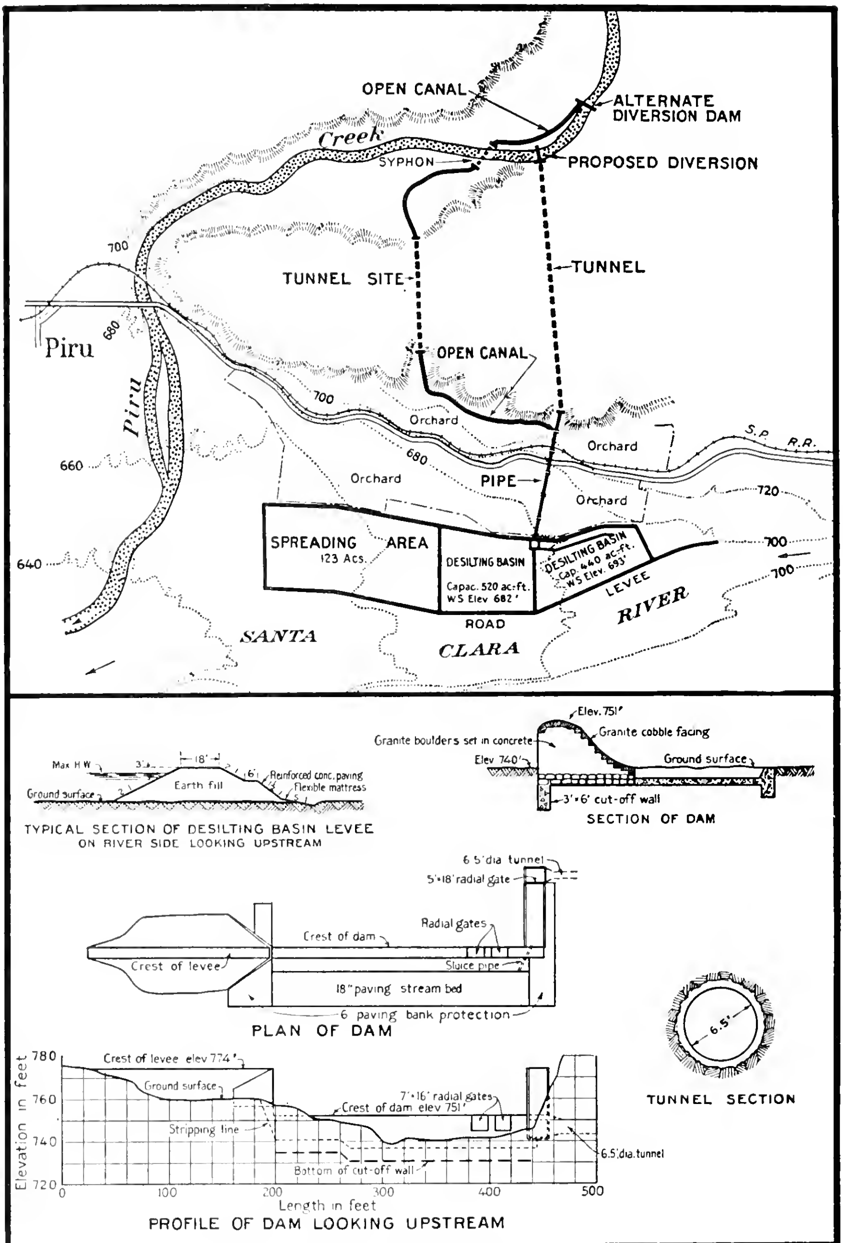
A pipe outlet from the upper basin is proposed to make it possible to draw off the remainer of the water. Ten overflow spillways from the lower basin would be used to supply the spreading ground. Otherwise the outflow provision for the lower basin would be similar to the upper basin.

Strip levees two or three feet in height in the 123 acres of proposed spreading ground would make it possible to use either channel spreading or still water ponding. Capacity of works is based on absorption in the spreading grounds of two feet in depth per day.

An alternate plan proposes diversion on the west side of Piru Creek further upstream, conveyance of water by open lined canal to a crossing of the creek back to east side, whence an open lined canal would convey the water to a point where the ridge between the creek and spreading grounds could be pierced by a 2200-foot tunnel, thence a canal on side hill to the same point reached by the other plan.

This plan is estimated to cost $413,000 exclusive of lands and rights of way. It is believed it would be more expensive to operate than the plan proposed.

PLATE XXXVII



STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

VENTURA COUNTY INVESTIGATION

PROPOSED SPREADING WORKS
NEAR PIRU

Montalvo Basin

A diversion dam with four 55-foot width floodway openings is proposed at the present site of the Lloyd-Butler Ditch intake. The bottom of these openings would be approximately two feet above the river bed and flood water levels would be increased but little. Roller-crest control would enable the water level to be raised four feet above the permanent crest, to elevation 156.

The structure would include extraordinary provision against destruction by erosion. Cut-off walls and sheet piling to a depth of 20 feet below the river bed and reinforced concrete piling under the piers to a depth of 35 feet are proposed.

A 20-foot by 6-foot taintor gate would provide a sluiceway adjacent to the canal intake and a smaller taintor gate would control the canal intake.

On the north bank it would be necessary to extend a protected levee a few hundred feet upstream and one or two hundred feet downstream. On the southerly bank it is proposed to extend levee and bank protection from the diversion dam downstream along the desilting basins which would adjoin the river on the south.

A concrete lined canal with a capacity of 400 second-feet with bottom width of 15 feet, water depth of 5 feet, side slopes $1\frac{1}{4}$ to 1, and grade of 0.00025 would extend to the desilting basins. Control gates would regulate the flow three ways: to the basins, to Lloyd-Butler Ditch (or Camarillo Canal proposed as part of the ultimate county plan), and to the spreading grounds direct through a concrete lined bypass canal.

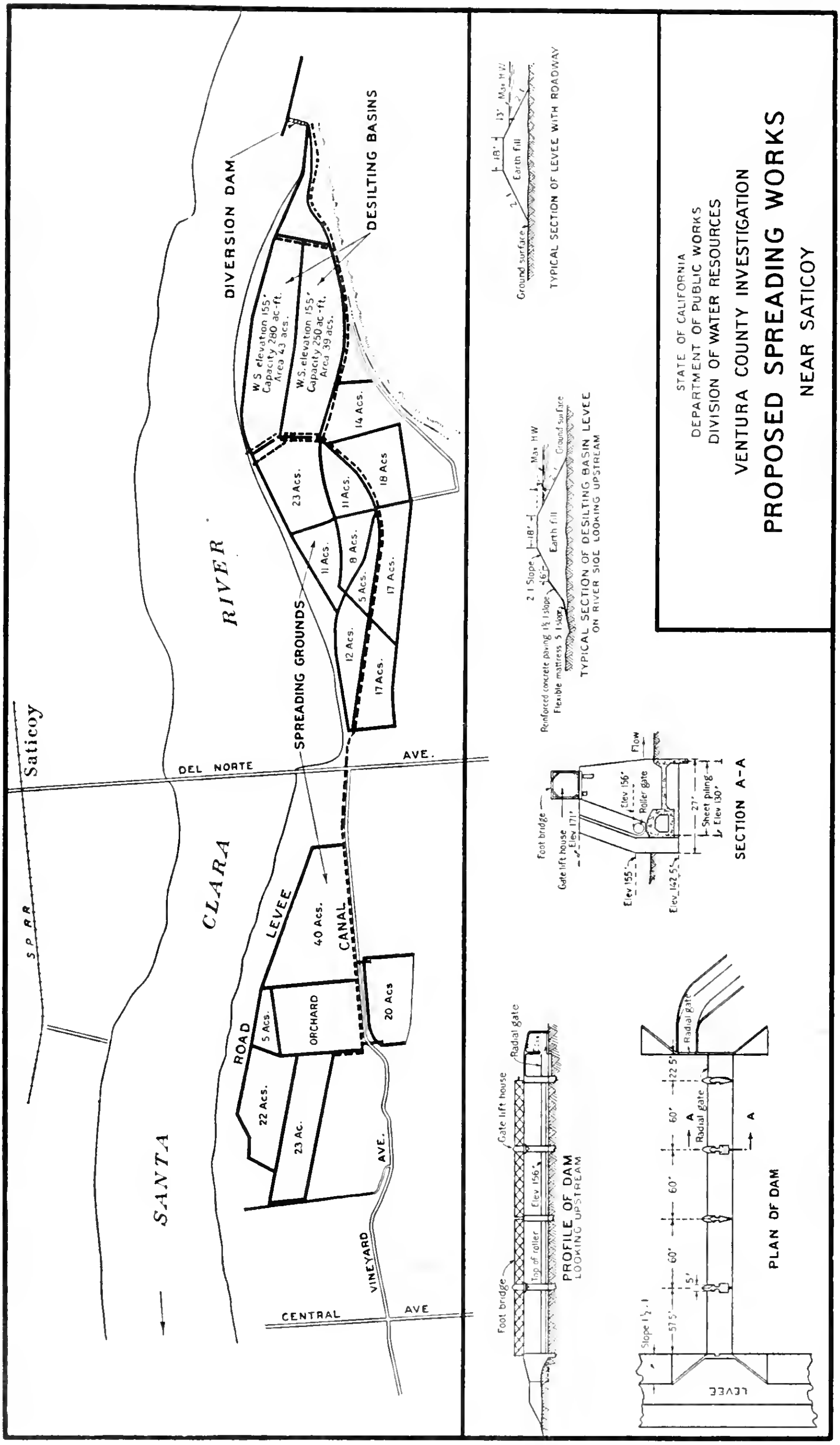
Provision of 530 acre-feet of storage for desilting the flood flows of the Santa Clara River water prior to spreading would be provided by two parallel desilting basins. The division levee and required structure in separating the storage into two basins add about $20,000 to the total cost but the opportunity for more flexible operation and the increased safety against interruption of spreading appear to justify the added cost. The larger basin adjacent to the river would have an area of 43 acres, a capacity of 280 acre-feet and a maximum water depth of 12 feet. The other, an area of 39 acres, a capacity of 250 acre-feet and a maximum water depth of 13 feet.

The levee sections for the basins would be similar to those for the Piru spreading works, but the fills would include a considerable volume of cobblestone. With some additional cost these might be used for riprapping portions of the levees where concrete paving and flexible wire mesh construction would not be required for protection against river erosion or they could be used as wave protection on the inside of the levee. Freeboard on the levees forming the basins would be three feet.

Large outlet pipes leading to the river would provide for sluicing sediment out of the desilting basins. This would be facilitated by strip levees which lead to a lip on concrete channels which discharge into the outlets. Flashboard controlled sluices at the upper end of the basins would make it possible to sluice the individual strips.

Outlets from the basins would be a combination of overflow spillway and deeper flashboard controlled sluices discharging into a con-

PLATE XXXVIII



crete lined collection canal which would connect with the main distributing canal at the lower end of the bypass canal.

The concrete lined bypass canal from the upper to the lower end of the desilting basins would have a capacity of 220 cubic feet per second, bottom width of 6 feet, depth 3 feet, side slopes $1\frac{1}{4}$ to 1 and grade 0.0025.

From the levee end of the bypass canal a concrete lined canal 6 feet bottom width, 2.5 feet depth, $1\frac{1}{4}$ to 1 side slopes, grade 0.003, 200 second-foot capacity, would pass through the spreading area lying above Del Norte Avenue. At the lower end of this spreading area the canal would be provided with a wasteway, discharging into the river bed and with an outlet to 120 second-feet canal extending down Vineyard Avenue to the spreading area below Del Norte Avenue.

The estimated cost of preparing the spreading grounds is based upon ponding in from one- to ten-acre blocks, with maximum water depth of about two feet. The outside levees and some interior ones would be wide enough for roadways. Strip levees with channel flooding could be provided for most of the area with no increase in cost over the proposed plan. Approximately 250 acres of spreading area are proposed of which 135 acres are above Del Norte Avenue and 115 acres below it. Additional areas could be secured in the river wash above Saticoy Bridge. Capacity of works is based on absorption in the spreading grounds of two feet in depth per day.

Upper Ventura River Basin

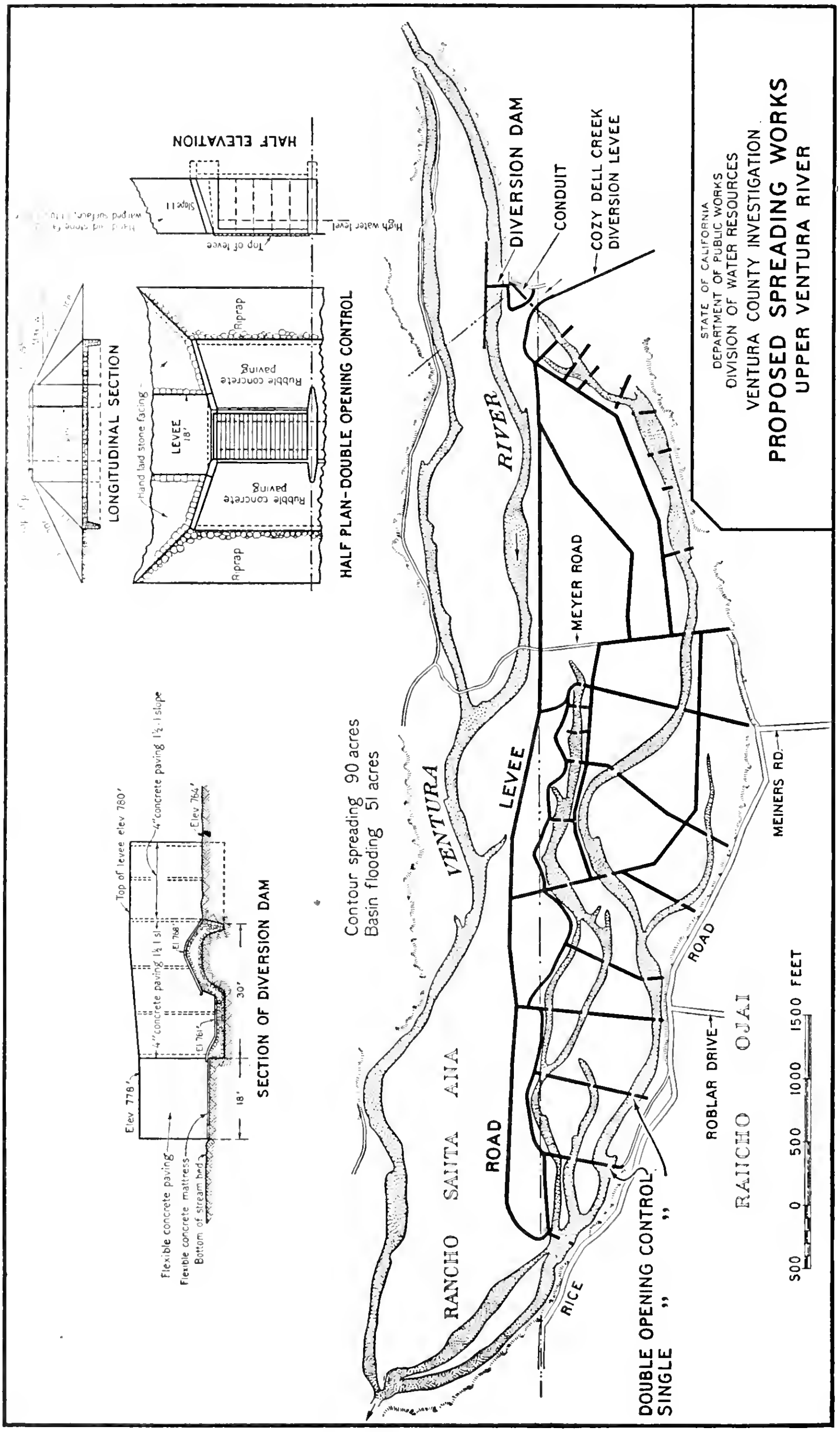
The location selected for the spreading development is the highest practicable one on the Ventura River, with a diversion dam located 1800 feet below the present diversion of Matilija Ranch.

The river bed elevation at the proposed diversion site is 764 feet. A rubble concrete masonry structure with old steel rails surface protection is proposed, with a crest elevation of 768 feet. The structure would be provided by a stilling pool with a flexible concrete mattress below it. Headgates for the spreading works diversions would have a total sill length of 32 feet and a depth of 2 feet below the crest of the dam. A 16-foot sluiceway with a sill 4 feet below the crest of the dam would be closed by a radial gate. A guide levee on the west side of the main channel would extend upstream from the end of the dam to the existing levee protection of the Rancho Santa Ana diversion works. Its crest elevation at the end of the proposed diversion would be 780 feet.

In order to avoid excessive spillway capacities for the main flooding levees, it is desirable to bypass the flood flows of the Cozy Dell Creek. By means of a diversion levee the flood flow of this creek may be kept in the most northern channel of its cone and carried across a covered section of the spreading works channel.

From the diversion dam to the southern end of the spreading grounds, a low road levee is proposed. In general it would be built on the highest ground lying between the main river channel and the spreading grounds. This would provide a considerable measure of protection from flood menace, and would provide access for the construction of flexible mattresses or other protection works at the threatened point.

PLATE XXXIX


STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
PROPOSED SPREADING WORKS
UPPER VENTURA RIVER
DIVERSION DAM
CONDUIT
COZY DELL CREEK
DIVERSION LEVEE
VENTURA
RIVER
LEVEE
MEYER ROAD
MEINERS RD.
ROAD
ROBLAR DRIVE
RICE
ROAD
RANCHO SANTA ANA
RANCHO OJAI
Contour spreading 90 acres
Basin flooding 51 acres
DOUBLE OPENING CONTROL
SINGLE " "
500 0 500 1000 1500 FEET
HALF ELEVATION
Top of levee
High water level
Slope 1:1
LONGITUDINAL SECTION
HALF PLAN-DOUBLE OPENING CONTROL
Riprap
Rubble concrete paving
LEVEE 18'
Hand laid stone facing
SECTION OF DIVERSION DAM
Elev 778'
Top of levee elev 780'
4" concrete paving 1½:1 slope
Elev 764'
El 768
4" concrete paving 1½:1 sl
El 761
18'
30'
Flexible concrete paving
Flexible concrete mattress
Bottom of stream bed

Main flooding levees would be constructed with top width of 18 feet and would be smoothed for roadways. The control structures would have "single lane" bridges over them. Guides of 4-inch, H-beams section would be provided for flashboard or gate control. Half of the 20-foot spans of the control openings included in the estimates and shown on the plan would be for use as overflow spillways and would have weirs without provision for flood-board control. It is possible that some other type of spillway could be constructed at less cost. The area flooded by these main levees, as shown, would be 50 acres and the volume of storage 127 acre-feet with a maximum water depth of about 9 feet for the larger basins. The mean depth for the entire flooded area would be 2.5 feet.

On an area of about 90 acres it is proposed that contour levees be constructed to a height of about 3 feet, with one foot freeboard. The average distance between 2-foot contours for this area is about 32 feet and therefore an average of little more than one-quarter of a mile of levee would be required for each acre flooded. These levees may be constructed by the use of a Martin Ditcher or by a road grader.

CHAPTER XIII

PLAN OF DEVELOPMENT

SANTA CLARA RIVER VALLEY, COASTAL PLAIN AND CALLEGUAS CREEK VALLEY

Hydrological Resume

As an introduction to a plan for development a brief resume of the hydrology of these areas follows:

The water supply of all the above areas is derived by pumping underground water which has penetrated by percolation from streams, or from rainfall on the valley floor. In addition to these sources, there is a supply produced by deep percolation of rain on the porous portions of the watershed above the valley in those areas where these formations also underlie the recent alluviums of the valley and transmit the water which has thus percolated to a point beneath the valley where it becomes available to pumps penetrating the alluvium or the porous older formation. Water from this source is believed to be a considerable item in all the basins of Calleguas Creek drainage area. Information sufficient to evaluate this supply is not available and hence no attempt has been made to calculate the surplus or shortage in Simi, Santa Rosa, West Las Posas, Las Posas, and Pleasant Valleys. It may be that present draft in Pleasant Valley and in the northern part of Simi Valley is greater than the long time average and that local sources are insufficient, which condition, if it exists, will eventually necessitate the importation of water if present agricultural development is maintained. In the other valleys above mentioned it is believed supply is equal to or greater than present demand but evaluations of supply have not been attempted. Use of irrigation water has been rapidly increasing in the recent past and rainfall has been deficient, either of which is sufficient to cause the water table to fall as it has done even without long-time deficiency. This obscures the true condition of these valleys.

Very little water from this drainage area wastes into the ocean, indicating that little conservation can be accomplished by reservoirs in the watershed or by spreading operations.

In Santa Clara River Valley natural percolation without conservation is sufficient for present irrigated area and for ultimate expansion with a large margin to spare for a forty-year period similar as to precipitation to that beginning in the fall of 1892.

With present irrigated area the average annual waste out of the valley for the 40-year period is estimated to have been 177,000 acre-feet of which 27,000 acre-feet was water which had percolated to the water table and reappeared at the lower end. The remainder was flood waste.

The estimated average annual waste from the valley in the ten years of drought beginning with 1922 is 73,000 acre-feet of which 52,000 acre-feet occurred in flood flows.

Not all of the discharge from Santa Clara River Valley wastes into the ocean. Most of the rising water and part of the flood flow again percolate and is the principal supply to Oxnard Plain.

Estimates of the supply to Oxnard Plain indicate that the long-time average is slightly less than pumping draft which occurred during the dry years of the investigation. A difficulty in Oxnard Plain may be prevention of intrusion of salt water from the ocean into the pumping strata as the water table lowers during long periods of drought. With present irrigated acreage and draft as it occurred during the investigation it is estimated that in a dry period similar to that which began in 1922 the requirement for this would be 9000 acre-feet annually on the average. For possible ultimate development it is estimated that this would require 17,000 acre-feet for a similar draft. It may be found in a recurrence of normal or above normal years of rainfall that the draft will be less which would reduce the foregoing estimates.

Discharge from the mountains is highly erratic. In the past forty years the period from 1893 to 1904 was one of drought, the period from 1905 to 1918 was one of prolific run-off and the period from 1919 to 1932 was again deficient. Records of precipitation indicate that prior to 1892 cyclic variation also occurred. In addition the annual variation is great. The estimated run-off of Santa Clara River for the most prolific year is over forty times the estimated run-off of the most deficient. Such a condition necessitates excessive storage capacity if a large percentage of the waste is to be conserved as to do this requires that the waste of prolific cycles be held for use in deficient cycles.

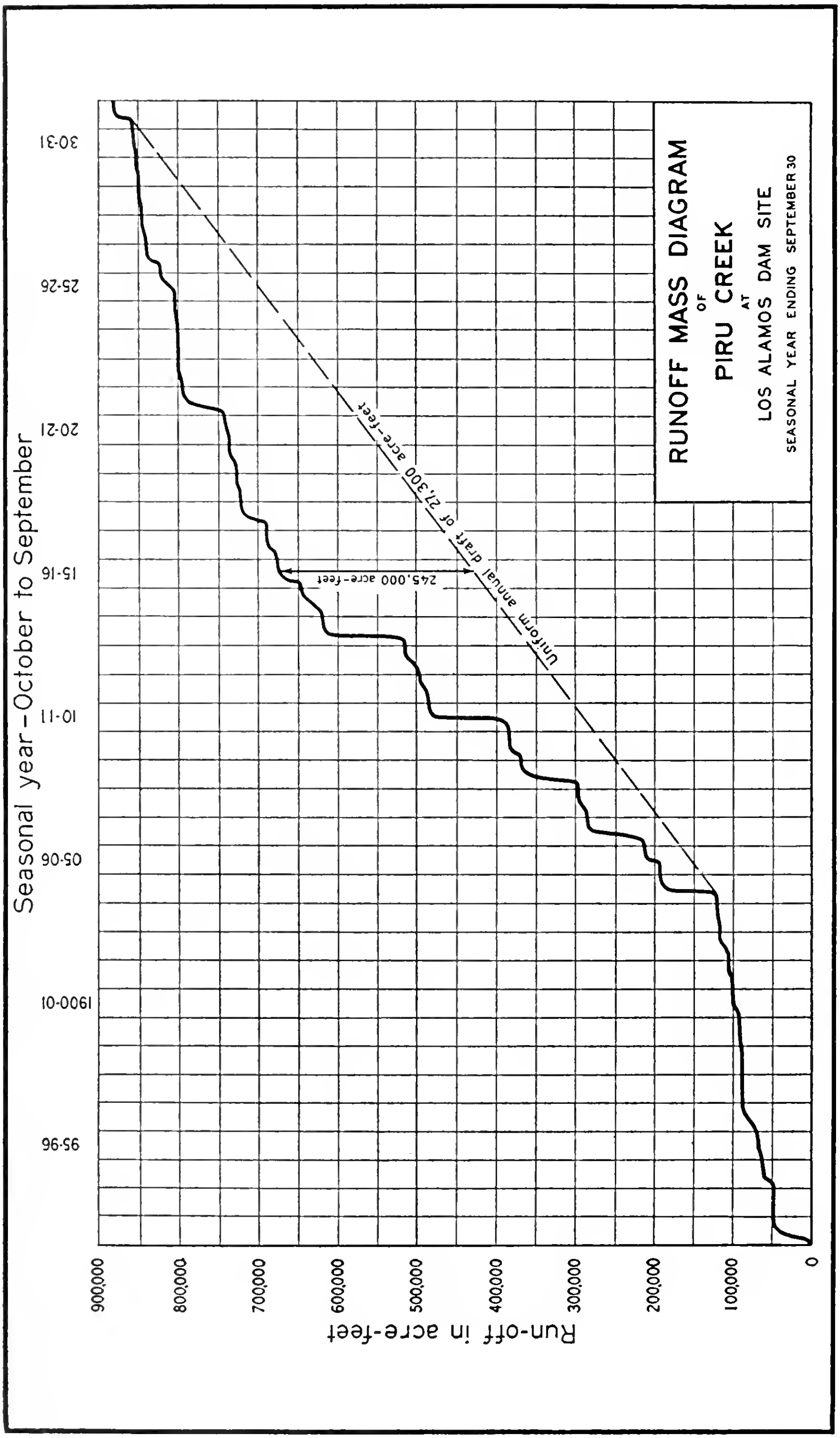
The Problem Stated

The problem presented is to so regulate and control the surplus of Santa Clara River Basin that it can be transported to the areas to the south now deficient or which may become deficient. Facilities available for control are surface reservoir sites on Piru and Sespe Creeks and the natural underground reservoirs now available in Piru Basin and Montalvo area as shown on Plate I, page 16, and Plate XXXVI, page 166, or underground space created by pumping. In both the areas mentioned the water table is sufficiently below the surface in dry cycles of years so that large reservoir capacity is available and conditions are favorable for artificial recharge. Once placed in underground reservoirs evaporation losses may be held to a minimum by proper manipulation while in surface reservoirs such loss is large if water is held over long periods.

Two general routes are available for transportation of the water to the south. One would transfer water across South Mountain at a point near the town of Fillmore in Santa Clara River Valley and land it on the other side in the general vicinity of the town of Moorpark. Pressure pipe lines, high pumping lifts and tunnels would be required. The area nearest the outlet would be the Moorpark-Somis area, that is, Las Posas Valley and the upper part of Pleasant Valley. The other

12—8367—8375

PLATE XL


RUNOFF MASS DIAGRAM
OF
PIRU CREEK
AT
LOS ALAMOS DAM SITE
SEASONAL YEAR ENDING SEPTEMBER 30
Uniform annual draft of 27,300 acre-feet
245,000 acre-feet
Seasonal year–October to September
30-31
25-26
20-21
15-16
10-11
05-06
1900-01
95-96
Run-off in acre-feet
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0

route would carry the water around the end of South Mountain after Santa Clara River Valley had secured its full demand. A gravity conduit would reach well to the eastern part of Pleasant Valley. (Plate IV, opposite page 26.) Santa Rosa Valley and the lower areas in the vicinity of Moorpark could be reached with comparatively small pumping lift. Most of the Oxnard Plain could be reached without artificial conduit, the water being transported underground through the aquifers as it is in a state of nature. Detail cost estimates were made of the second but not of the first plan.

Surface Reservoirs

No favorable reservoir sites exist on Santa Paula Creek. The work done on the sites on Piru Creek and Sespe Creek is discussed in detail in Chapter XI which gives careful estimates of cost of each reservoir with different types of dam and different capacities.

For the reservoirs on Piru Creek the curves indicate that for a capacity of 30,000 acre-feet the cost per acre-foot of capacity would be approximately as follows:

Spring Creek	\$108.00
Devil Canyon	135.00
Los Alamos	140.00

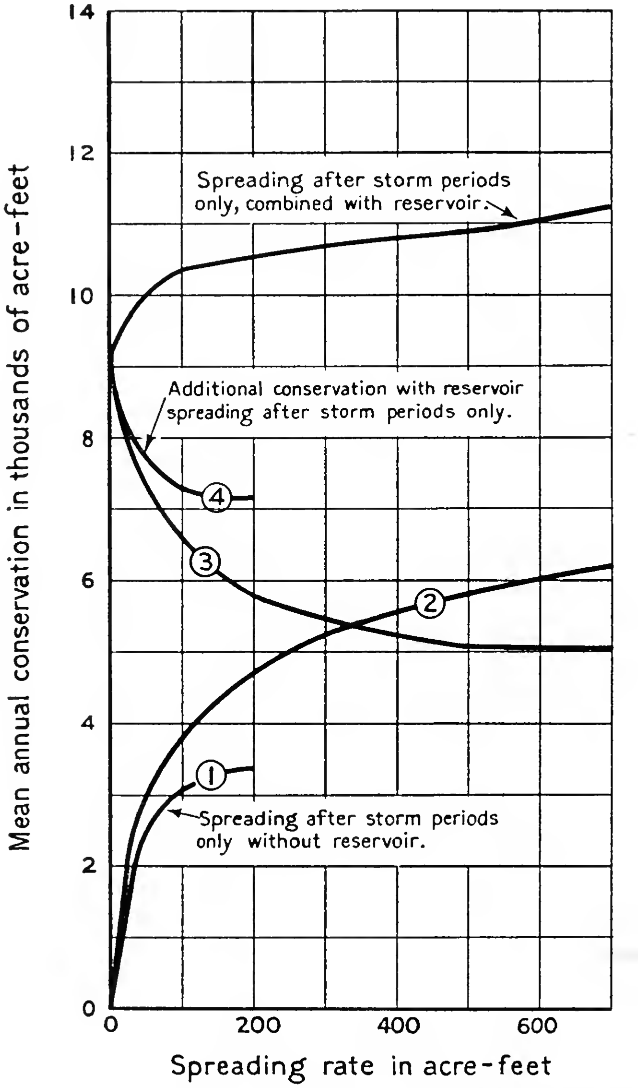
Blue Point site was estimated only for smaller capacities because of bad foundation conditions involved for a higher dam. At lower capacities the cost per acre-foot for Spring Creek becomes still more favorable relatively but at 40,000 acre-foot capacity Devil Canyon becomes the cheapest per acre-foot of capacity.

On Sespe Creek estimates were made for only Cold Springs and Topa Topa sites which show the former to be much cheaper per acre-foot of capacity than Topa Topa and cheaper for any capacity above 14,000 acre-foot than any of the reservoirs on Piru Creek.

On Plate XL is shown a cumulative mass curve of run-off at Los Alamos site on Piru Creek. To maintain a draft of 27,000 acre-feet per year would require a capacity of 245,000 acre-feet. No such capacity is possible from a physical standpoint and equally impossible from the standpoint of cost. Water would be held over in the reservoir for more than a quarter of a century and approximately half of it would be lost by evaporation leaving a usable yield of only 14,000 acre-feet. This curve is typical of all storage sites whether on Piru Creek, Sespe Creek or on Ventura River. At Devil Canyon a capacity of 525,000 acre-feet would be required to give a usable yield of about 28,000 acre-feet.

From this analysis and because of the small reservoir capacities as shown by surveys and the large cost per acre-foot as shown by estimates it is concluded that, if built, surface reservoir capacities should be only sufficient to control the waste of the dry cycles. The ten and half-year period from spring 1922 to fall 1932 was therefore selected for study. A similar deficient period occurred from 1893 to 1904 but data are more reliable for the later period and during five years of it the investigation was under way giving opportunity to intensively observe all hydrological phenomena.

PLATE XLI



PIRU CREEK

MEAN ANNUAL CONSERVATION

AVAILABLE FOR PERIOD 1922-1932

BY SPREADING NEAR PIRU

AND WITH 30,000 ACRE-FOOT RESERVOIR AT DEVIL CANYON

Piru Creek

The results of various studies of amount of Piru Creek water which could be conserved by reservoirs of various capacities, spreading works of various capacities and combinations of the two are shown on plates in the following pages. All studies are for the deficient period 1922–1932.

The plates on pages 120 and 122 give total cost of all reservoirs for different capacities and for different types of dams, and cost per acre-foot of capacity for these same capacities and types. However, the cost wanted is the cost per acre-foot of yield rather than of capacity.

The word "yield" as used in this case is not the same each year but the annual average for all the years of the period analyzed. It is extremely variable year by year. The discharge of the run-off season 1921–22 was sufficient to have filled any reservoir of reasonable size and in each study the reservoir was assumed full at the end of that run-off season. The reservoir was then assumed to be emptied as fast as the ground water basins below could absorb it either naturally or by the help of spreading works. Each subsequent year the same process was repeated. This would result in minimum evaporation loss and the highest potential salvage inasmuch as the reservoir would be empty each fall and in a position to retain the entire run-off of the following season up to capacity or even more than capacity since the contents might be partially emptied between storms.

The result of this method of operation would be to make the surface reservoirs merely adjuncts to the ground water reservoirs. The yield is a result of the combination of the two and should not be entirely credited to the surface reservoir.

Plate XLI shows the average acre-feet of water which would be conserved annually by spreading works of various capacities diverting from Piru Creek alone and also combined with Devil Canyon Reservoir. Curve 1 shows the estimated conservation if spreading could be done on all days when the flow of the creek would not all naturally percolate. Curve 2 shows the estimated conservation if diversion could not be made until the stream had settled after floods. The average period required for settlement was assumed to be $5\frac{1}{2}$ days but for certain years it would be much longer. This average period is based on study of each individual year.

Curve 3 shows the conservation which would be made by a 30,000 acre-foot reservoir itself at Devil Canyon in conjunction with spreading works which could not be operated all days and Curve 4 shows the conservation of the same reservoir in conjunction with spreading works which could be operated all days when water would not naturally all percolate. Curve 5 shows the total combined conservation of reservoir and spreading works under both conditions.

The following tabulation shows for the smaller spreading rates the information from which the curves were drawn;

PLATE XLII

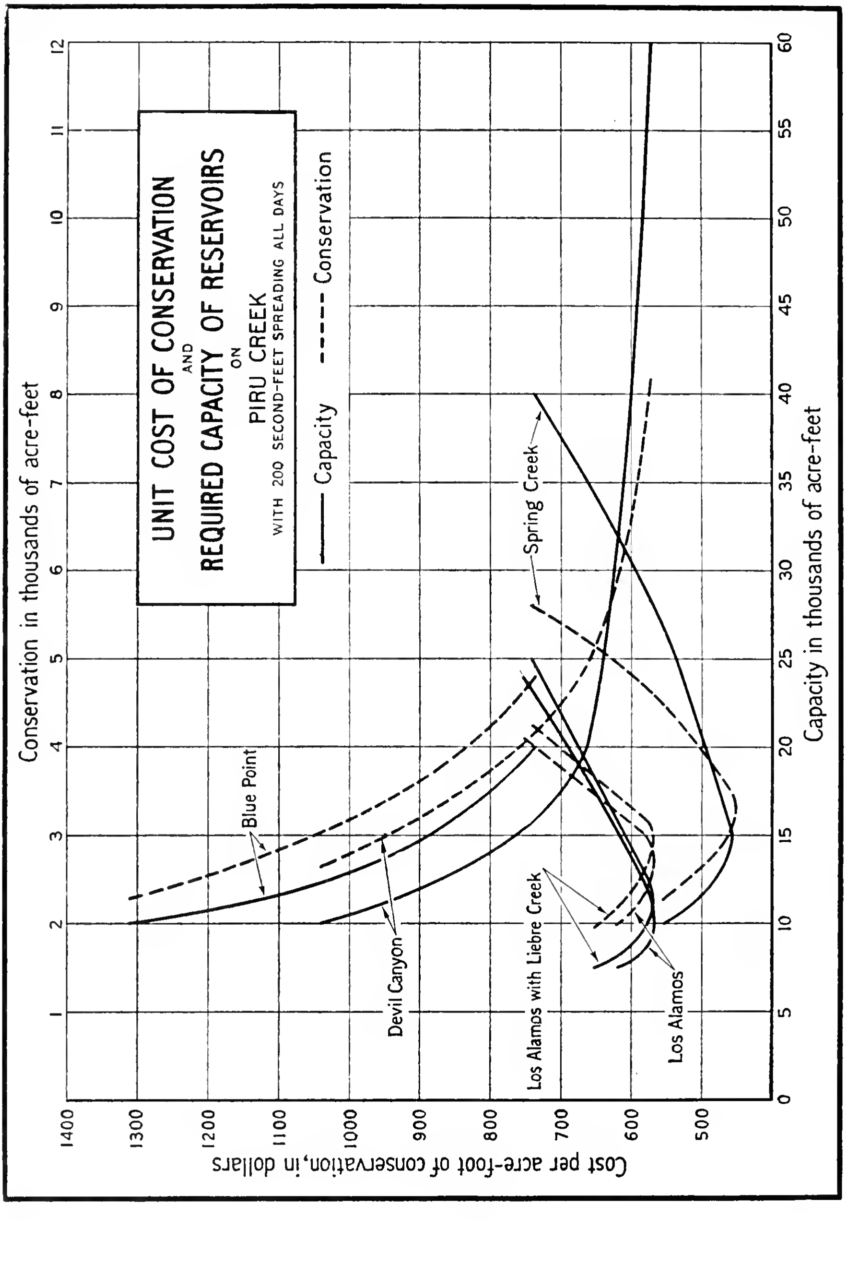


Illustration of use of curves. To find conservation and cost per acre foot for Spring Creek reservoir of 25,000 acre feet capacity: Read upward on vertical ordinate marked 25 on bottom of graph, to intersection with solid line marked "Spring Creek" thence horizontally to dashed line similarly marked, thence vertically to top of graph giving 4300 acre feet conservation. From same point on dashed line read horizontally to $525 per acre foot.

TABLE 43

PIRU CREEK CONSERVATION—SPREADING WORKS ALONE AND IN COMBINATION WITH DEVIL CANYON RESERVOIR, 30,000 ACRE-FOOT CAPACITY

Second-feet spreading capacity	Acre-feet conservation—average per annum, 1922-32		
	Spreading works alone	Additional by Devil Canyon Reservoir	Combined Devil Canyon Reservoir and Spreading
0	0	9,170	9,170
100	3,780	6,570	10,350
200	4,770	5,770	10,540
300	5,230	5,470	10,700
400	5,540	5,240	10,780

Incidentally the first figure under the heading "Additional by Devil Canyon Reservoir" is the yield of a reservoir of that size without spreading. From the cost estimate of the reservoir the cost per acre-foot of salvage by reservoir alone can be calculated. In the following table this is shown together with the same information for Spring Creek Reservoir for which a similar study was made.

TABLE 44

COMPARATIVE COST AND AMOUNTS OF CONSERVATION, SPRING CREEK AND DEVIL CANYON RESERVOIRS WITHOUT SPREADING

Name	Acre-feet		Cost	
	Approximately most economic capacity	Conservation, average, 1922-32	Total	Per acre-foot of conservation
Spring Creek	15,000	4,900	$1,550,000	$316
Devil Canyon	30,000	9,170	3,600,000	392

NOTE.—The Spring Creek Reservoir cost is for the cheapest type of several dams on which estimates were made. Only one type of dam was used in estimates for Devil Canyon.

After consideration it was decided that further studies should be on the basis that spreading works could be made to function on all days when water was available and that the diversion would be 200 second-feet although as explained in Chapter XII the diversion capacity would actually be 300 second-feet. All subsequent studies are based on spreading 200 second-feet. In these studies water is assumed to be held in the reservoir only when the discharge exceeds 200 second-feet plus natural stream bed percolation.

Plate XLII shows the unit cost of conservation of all reservoirs investigated on Piru Creek, assuming that they salvage only the water which could not be salvaged by spreading. The lowest point on the curves also shows the most economic capacity of each reservoir. The following table is taken from the supporting data for these curves.

TABLE 45

PIRU CREEK, COMPARATIVE COST OF CONSERVATION BY RESERVOIRS, SPREADING GIVEN PRIORITY

Name	Approximately most economic capacity, acre-feet	Total cost	Conservation, acre-feet	Cost per acre-foot, conservation
Los Alamos with Liebre Creek diverted to it	11,600	$1,710,000	3,000	$570
Spring Creek	15,000	1,550,000	3,470	455
Blue Point	*20,000	3,500,000	4,800	730
Devil Canyon	30,000	3,600,000	5,770	625

* Not most economic but capacity limited by geological conditions.

Sespe Creek

The results of various studies of amount of conservation of Sespe Creek water which could be effected by reservoirs of various capacities, spreading works at Montalvo Basin of various capacities and combinations of the two, are shown on plates in the same way as the same information was shown for Piru Creek. All studies on Sespe Creek are also for the deficient period 1922–1932.

The plates on pages 120 and 122 give total cost of all reservoirs with different types of dams and costs per acre-foot. As with Piru Creek it is cost per acre-foot of yield which is important and not cost per acre-foot of capacity.

In estimating yield the reservoirs on Sespe Creek were assumed to be emptied in the same way as those on Piru Creek and the discussion on page 181 applies equally to Sespe Creek conservation.

Plate XLIII shows the average acre-feet of water from Sespe Creek which would be conserved by spreading works of various capacities diverting from Santa Clara River in the Montalvo area near the town of Saticoy, alone and also combined with surface reservoirs on Sespe Creek. Curve 1 shows the estimated conservation if spreading can be done on all days when the water would not naturally percolate. Curve 2 shows the estimated conservation if spreading could not be done during floods and until the stream had settled to a steadily decreasing flow thereafter. In estimating the days on which spreading could not be done the run-off of each year of record was inspected and for those years in which no records are available a proportionate number of days allowed depending on the flood discharges of Sespe Creek for which records are available. The average number of days per year in which it was assumed that no spreading would be attempted is six and one-half but in some years it is much more. As a basis for further studies it was assumed the accomplishment of the spreading works would be based on 200 second-feet diversion not operated during flood periods.

Curve 3 shows the combined annual conservation accomplished by Cold Spring Reservoir, capacity of 40,000 acre-feet, combined with spreading works if they could function all days when water was present. Curve 4 shows the amount of conservation in the combination

due to the reservoir. Curves 5 and 6 give the same information, respectively, for Cold Springs Reservoir built to 40,000 acre-foot capacity and Topa Topa built to 20,000 acre-foot capacity.

The supporting data for these curves are given in the following tables:

TABLE 46

SESPE CREEK CONSERVATION—SPREADING WORKS ALONE AND IN COMBINATION WITH COLD SPRING (40,000 ACRE-FEET) AND TOPA TOPA (20,000 ACRE-FEET) RESERVOIRS

Second-feet spreading capacity	Conservation—acre-feet—average per annum, 1922–1932				
	Spreading works alone	Additional by Cold Spring Reservoir	Combined Cold Spring and Spreading	Additional by Cold Spring and Topa Topa Reservoirs	Combined Cold Spring and Topa Topa and Spreading
0	0	11,500	11,500	22,000	22,000
100	10,300	9,500	19,800	18,700	29,000
200	12,600	8,600	21,200	18,600	30,200
300	14,500	8,000	22,500	16,600	31,100

NOTE.—Spreading works not operated during floods.

Incidentally the first figures in the two columns which show conservation by reservoirs alone are the yields of the reservoirs of that size without spreading and from the cost estimate of the reservoirs the cost per acre-foot of salvage by reservoir alone can be calculated.

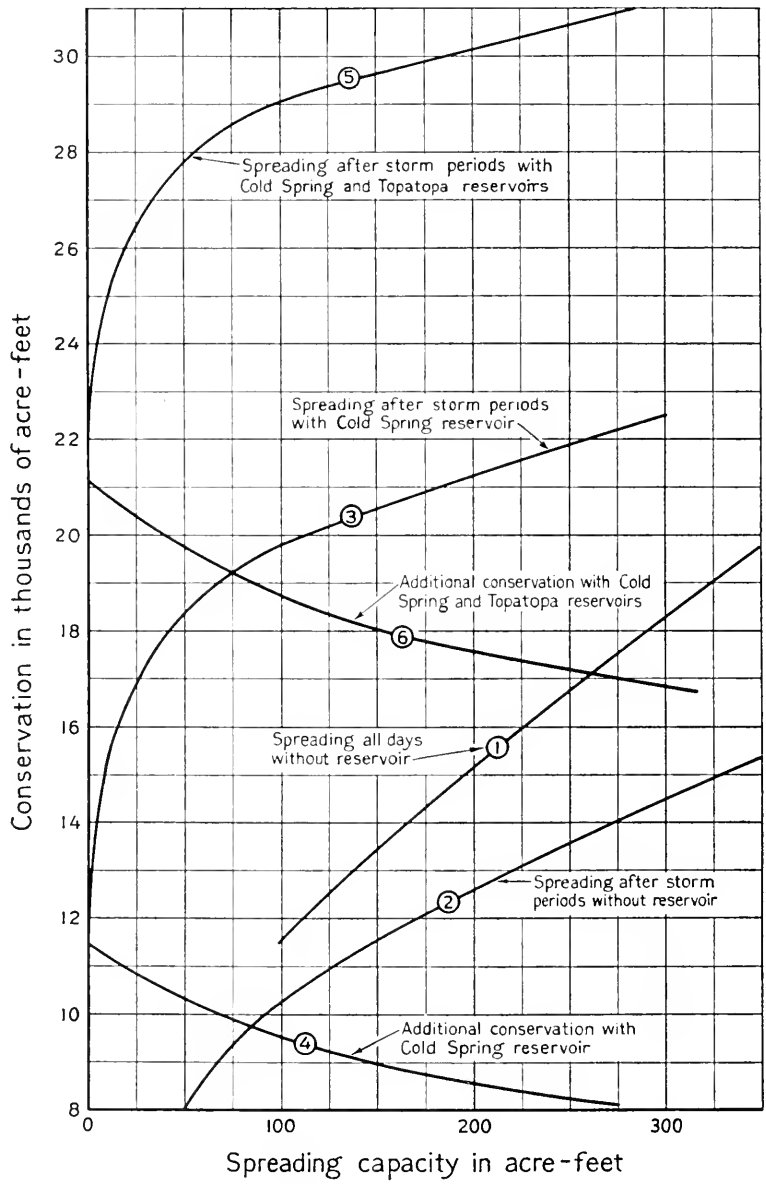
TABLE 47

COMPARATIVE AMOUNTS OF SALVAGE, COLD SPRING RESERVOIR ALONE AND COMBINATION OF COLD SPRING AND TOPA TOPA RESERVOIRS WITHOUT SPREADING

Name	Approximately most economic capacity, acre-feet	Total cost	Conservation, acre-feet	Cost per acre-foot of conservation
Cold Spring	40,000	$1,920,000	11,500	$167
Cold Spring	40,000	$1,920,000		
Topa Topa	20,000	3,860,000		
Combined	60,000	$5,780,000	22,000	263

Plate XLIV, page 187, shows the unit cost of conservation for different capacities in combination with spreading works of 200 second-feet capacity at Saticoy not operating during floods and assuming that the reservoirs salvage only water which could not be salvaged by spreading works without reservoirs. Most of the information is for a 40,000 acre-feet reservoir at Cold Spring combined with various capacities at Topa Topa. However, a study was made of a 30,000 acre-foot reservoir at Cold Spring site combined with a 30,000 acre-foot reservoir at Topa Topa and the results are shown on the graph. This increases the yield but also the unit cost. The plate also shows the most economic size of reservoir.

PLATE XLIII



SANTA CLARA RIVER

MEAN ANNUAL CONSERVATION

FOR PERIOD 1922-1932

AVAILABLE BY SPREADING NEAR SATICOY
AND WITH RESERVOIRS ON SESPE CREEK
40,000 ACRE-FEET CAPACITY AT COLD SPRING AND 20,000 AT TOPATOPA

PLATE XLIV

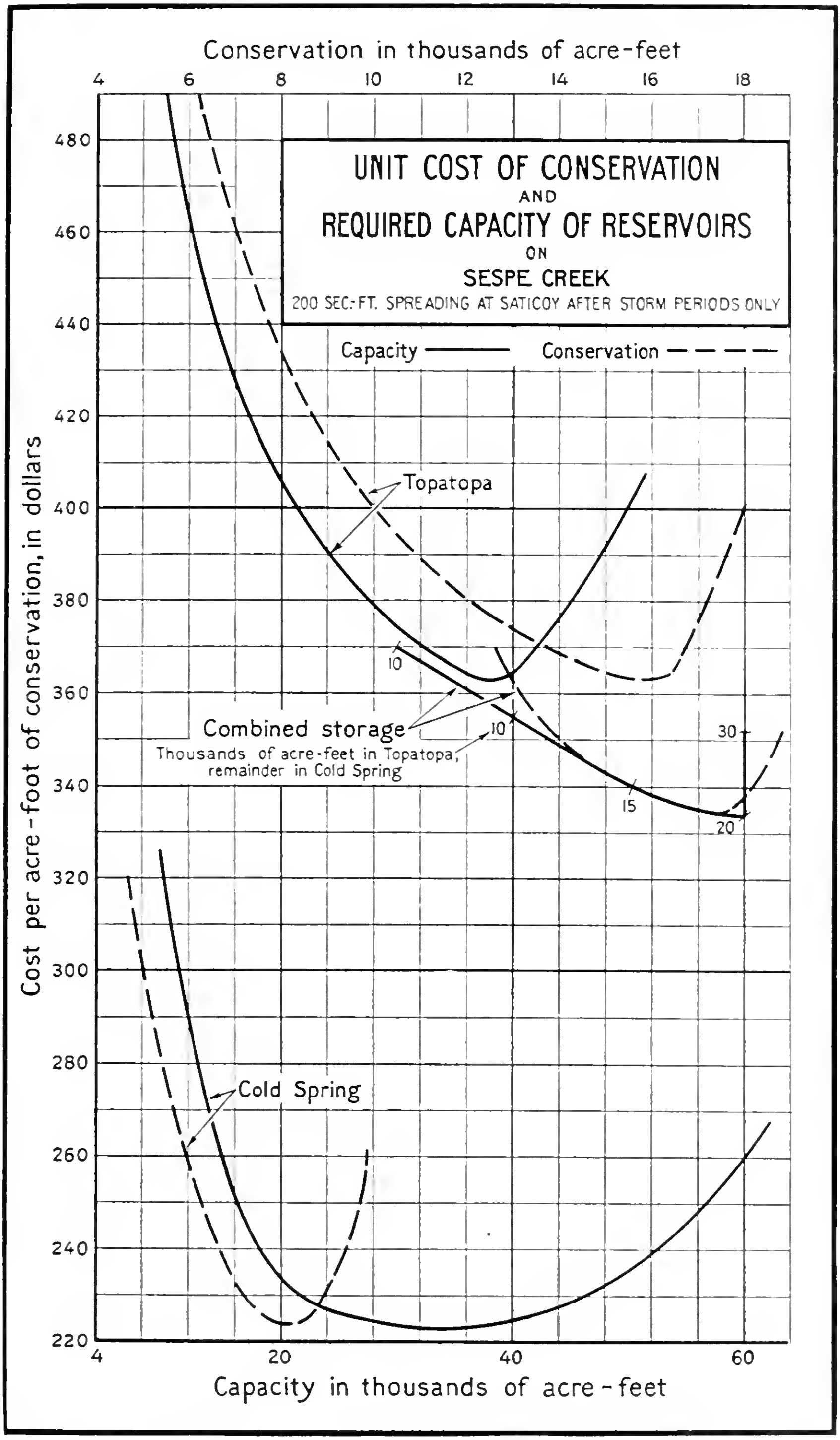


Illustration of use of curves. To find conservation and cost per acre foot for Cold Spring reservoir of 48,000 acre feet capacity: Read upward from bottom of graph on vertical ordinate 48 to intersection with solid line marked "Cold Spring" thence horizontally to dashed line similarly marked, thence vertically to top of graph giving 9100 acre feet conservation. From same point on dashed line read horizontally to $232 per acre foot.

TABLE 48

SESPE CREEK, COMPARATIVE COST OF CONSERVATION BY RESERVOIRS, SPREADING GIVEN PRIORITY

Name	Approximately most economic capacity, acre-feet	Total cost	Conservation, acre-feet	Cost per acre-foot, conservation
Cold Spring	40,000	$1,920,000	8,600	$224
Topa Topa	40,000	6,000,000	16,400	366
Cold Spring	40,000	1,920,000		
Topa Topa	20,000	3,860,000		
Combined	60,000	5,780,000	17,500	330
Cold Spring	30,000	1,760,000		
Topa Topa	30,000	4,850,000		
Combined	60,000	6,610,000	18,800	352

The cost of conservation and amounts on all different reservoirs and spreading works are brought together for comparison in the following table:

TABLE 49

COMPARATIVE COSTS OF CONSERVATION

Investigated Reservoirs and Spreading Works

Name	Approximately most economic capacity of reservoir, acre-feet	Average annual conservation, 1922–1932	Cost per acre-foot of conservation
Piru Creek—			
Los Alamos	11,600	*3,000	$570
Spring Creek	15,000	3,470	455
Blue Point	20,000	4,800	730
Devil Canyon	30,000	5,770	625
Sespe Creek—			
Cold Spring	40,000	8,600	224
Cold Spring and Topa Topa combined	60,000	17,500	330
Spreading Works (see Chapter XII)			
Piru		4,800	84
Montalvo		12,600	28

* Includes Liebre Creek diversion.

Even after allowing for wide variation between estimated conservation by spreading and actual performance and adding also a reasonable extra sum per acre-foot for operation and maintenance, two definite conclusions may be drawn from the foregoing:

1. Spreading works are the cheapest items in the construction program per unit of conservation and Montalvo works should be preferred to Piru works.

2. Cold Spring Reservoir is the most favorable for construction of any surface reservoir and Topa Topa is next.

There is another conclusion of importance, but before stating it, reference is made to Chapters VIII and XII wherein water supply of Santa Clara Valley and spreading works are discussed. Analysis indi-

cates that the total conservation estimated during dry cycles for Piru Creek would not drift downstream with sufficient rapidity to become available to Oxnard Plain if the dry cycles of the future are comparable in length to that from 1894 to 1904 or to the present dry cycle if it does not extend many years into the future. It would finally reach Montalvo Basin but if it did so after the water table had raised due to a wet cycle the need for it would have passed, the basin would be full and the water in question would waste into the ocean. As development goes on and the water table is lowered further in Piru Basin, and to an extent in Fillmore and Santa Paula Basins, more of the water spread in the dry cycles would be intercepted before reaching Oxnard Plain or Saticoy diversion works and the benefit of such works to the areas to the south and to Oxnard Plain would decrease, assuming that Oxnard Plain water table is never pumped so low that there is possibility of sea water encroachment.

Estimated conservation by surface reservoirs on Piru Creek shown on Plate XLI is assumed to be done in conjunction with spreading, that is, it is assumed that their water is emptied and caused to percolate in the Piru spreading works as soon as possible. If this is done, a part at least will never become useful to the lower and southerly areas for the same reason that the water spread without reservoirs will not. The results of studies made for this report for the 40-year period 1892–1932 indicate that there would be no shortage in Santa Clara Valley for a similar period and that there is no possibility of it unless rainfall becomes much more deficient than that so far recorded. Consequently conservation of Piru Creek water, aside from incidental local advantages, would be only for areas elsewhere which are short of water supply. To get full benefit to these areas Piru Creek water conserved in surface reservoirs would have to be transported from Piru Canyon to place of use. Therefore the following additional conclusion may be made:

3. To the foregoing cost estimate of conservation of Piru Creek water the cost of a 25-mile conduit from Piru Canyon mouth to the proposed Saticoy diversion should be added. Without this the estimated salvage is larger than the actual amount that will be available to supply shortages.

Pumping in Santa Paula Basin

The underground storage capacity unoccupied is comparatively small in Santa Clara Valley and Coastal Plain and can not be increased except by more severe drought than has occurred in the period of record or by additional draft to lower the water table. The amount of lowering permissible is limited by possibility of salt water intrusion in the Oxnard Plain and by cost of pumping in Piru Basin so that at best the capacity in these areas to care for possible ultimate development of areas to the south, is insufficient during dry cycles.

Additional capacity could be created by pumping Santa Paula Basin if additional water becomes necessary after spreading works are installed. This would lower the water table and increase conservation in two ways: The willows which border the stream would be killed and the water now consumed by them would be available for beneficial use;

there would be an area provided in the river wash into which additional percolation could take place.

If such pumping were done it would be done only for transportation of the water to Oxnard Plain, Pleasant Valley and other areas south of South Mountain. No immediate necessity for this conservation is apparent and it remains a matter for study as time goes on. It involves legal and physical complications but these are not insoluble. The physical cost per acre-foot would be less than could be secured at any surface reservoir available.

Such pumping would decrease the salvage of the spreading works below but would increase the total salvage possible in the lower river. Some additional cost would be incurred by pumping the water from Santa Paula Basin which would otherwise have reached the spreading works. Against this those who received this water on the surface would be relieved of present pumping cost and could afford to finance the project to an equal amount.

As a basis for estimate of cost the following plan was laid out: A maximum pumping drawdown of 60 feet by a combined plant capacity of 75 second-feet from 30 wells, together with conveyance channel capacity of that amount from the wells to a point about one mile west of Camarillo and thence 25 second-feet capacity to a point along Camarillo Road about 1½ miles east of Calleguas Creek. A diversion canal extending from the Turner Ditch intake on Santa Clara River, about three-fourths mile above Willard Bridge at Santa Paula, with a capacity of 40 second-feet would connect with the river bottom pipe conduit which would collect the water from the pumping units. The estimated cost is $954,000. (See Plate IV.)

Reservoir on Conejo Creek

A reservoir site on Conejo Creek, about five miles southeast of the town of Somis, was surveyed and found to have a capacity of 8280 acre-feet. The estimated cost is $808,000.* The supply to it from Conejo Creek is negligible and if the site is used, water must be conveyed to it from Santa Clara River. There are other possible sites in and north of Camarillo Hills and to the east of Somis which have not been surveyed.

Conduit from Santa Clara River to the South

The reservoir could be utilized for storing water diverted from Santa Clara River during the winter season. It is estimated that a 200 second-foot conduit from the Saticoy diversion operated only during floods when the spreading works could not operate and at other times when water was available in excess of capacity of spreading works would divert an average of 3400 acre-feet per annum from Santa Clara River during the period 1922–1932 but the capacity of 8280 acre-feet would be required to accomplish this conservation. The cost of the conduit given in detail on page 222 is estimated at $1,300,000. Its location is shown on Plate IV which shows also the location of the reservoir. The conduit would start from the end of the conduit conveying water to the Saticoy spreading works, thence skirt South Mountain through difficult construction between South Mountain and Camarillo Hills,

* See page 238 for detail estimate.

thence a 2300-foot lined tunnel through Camarillo Hills, thence rather difficult construction along the south side of the hills to the flat of upper Pleasant Valley, thence across the flat to a pumping plant which would lift the water 87.5 feet to the reservoir through a 2800-foot pipe line 7.5 feet in diameter and an 800-foot lined tunnel into the reservoir. The tunnel and pipe line would be used as the reservoir outlet. The canal would be lined and pipe lines used where it passed near farm buildings.

The alternative 75 second-foot canal similarly constructed along the same route was estimated to cost $583,000. Detail is given on page 222. This would receive its supply by the pumping from Santa Paula Basin and by gravity diversion above the town of Santa Paula as previously described. The water would be used for gravity irrigation of Pleasant Valley. Winter diversion would not be made through this conduit and the reservoir above mentioned would not be used. If it were desired to utilize the reservoir the canal would be enlarged and extended to it from some point beyond Camarillo Hills.

The two plans may be summarized and compared but the comparison is not exact because estimates have not been attempted of cost of pumping, cost of the additional pumping necessary in Santa Paula Basin to supply present users whose costs might be increased by lowering the water table, or cost of the additional pumping necessary to make up for the spreading which could not be done in Saticoy spreading grounds if Santa Paula Basin were pumped. As against these is the reduction in cost of pumping by those who would receive gravity water through the conduit.

The combined capacity of the gravity diversion near the city of Santa Paula and the pumping equipment in Santa Paula Basin is assumed to be 75 second-feet.

TABLE 50

COMPARISON OF COST, TWO PLANS FOR TAKING WATER SOUTH THROUGH CONDUIT FROM SANTA CLARA RIVER

	Pumping equipment	Conduit from Santa Clara River to Camarillo Reservoir	Reservoir	Total
Plan I		$1,300,000	$808,000	$2,108,000
Plan II	$371,000	*583,000		954,000

* Does not reach reservoir.

Salvage by Plan II could be almost any reasonable amount because of the large capacity of underground reservoir which could be made available. In addition it would deliver water by gravity during the irrigation season. Plan I would require Cold Springs Reservoir in addition to make it worth while and to more fully utilize the conduit. It could likewise deliver a large proportion of water in the summer. Assuming that 12,000 acre-feet can be made available by either plan if Cold Springs Reservoir is built, the comparative total cost is estimated as follows:

	Capital cost
Plan I—Reservoir	$4,028,000
Plan II—Pumping	954,000

Operating costs for Plan II would be higher than for Plan I.

Sequence of Development

In the foregoing pages of this chapter the estimated cost and the estimated conservation of all features investigated in Santa Clara Basin and valleys to the south have been presented. These include the most feasible surface reservoirs, spreading works, pumping installation and two sizes of conduit from Santa Clara River to the south. From these the cost and conservation of any combination can be approximated. Following is a brief summary in which the various steps are set down in the order in which it is believed they should be constructed if demand develops. All estimates of conservation are for a period similar to the dry series of years spring 1922 to fall 1932.

1. *Spreading Works in Montalvo Basin.* The estimated average annual conservation is 12,600 acre-feet. This would provide for present estimated shortage in Oxnard Plain and also keep the water table in the Montalvo Basin at sufficient elevation so that there would be a gradient toward the ocean to the south and west of Montalvo Basin which it is believed would guard against marine intrusion into the pumping strata. The estimated maximum amount required for this 9000 acre-feet per annum so that the estimated amount salvaged by these works leaves some margin.

The cost is estimated at $348,000.

2. *Spreading Works at Piru.* The estimated average annual conservation is 4800 acre-feet. There is no long time deficiency of recharge of underground water at present in Santa Clara River Valley nor is it believed that there will be a deficiency for ultimate future development. However, the water table lowers in dry cycles, thereby increasing pumping cost and quality of underground water deteriorates as the water table lowers. Artificial recharge will benefit this to an extent. In addition a part of the water salvaged by these works would reach the Saticoy spreading works during the dry cycle and benefit Oxnard Plain in the future. It is believed from analysis of the matter that approximately half of the salvage in Piru Basin would reach Oxnard Plain in the dry cycle with present development giving an annual total, with the Montalvo Basin spreading works, of 15,000 acre-feet of new water on the average to the plain. It is also believed that the benefit from Piru spreading works will decrease as development goes on but the ultimate amount is difficult to evaluate. Careful consideration should be given to comparative cost and benefits before construction is undertaken. Estimated cost is $401,000.

Further development in Santa Clara Valley will decrease the present supply to Oxnard Plain and further development in Oxnard Plain will increase the demand. It is estimated that for ultimate development, average annual conservation during dry cycles similar to 1922–32 of 17,000 acre-feet will be required for Oxnard Plain to guard against marine intrusion unless as seems possible, draft in wet cycles is less than found during the investigation. Against this the spreading

works are estimated to conserve less than 15,000 acre-feet for the ultimate. To make a balance a new supply must be sought at that time if the foregoing estimates are correct unless pumping draft in wet cycles should be smaller than during the investigation, thus allowing the basin to fill at such times and decreasing the amount needed in dry cycles.

If the situation has been correctly evaluated the next step is distant in the future. No immediate need for additional water appears to exist in Pleasant Valley or any valleys to the south whether they are permanently overdrawn or not. Until the pumping lift becomes considerably greater than present, water can be obtained in such valleys by present practice probably more cheaply than it can be imported from Santa Clara River.

When and if the time arrives to conduct water to the south consideration should be given to the comparative merits of building surface reservoirs to conserve it or creating new underground reservoir capacity in Santa Clara River Valley below the city of Santa Paula. Reference is made to the preceding discussion in this chapter of pumping in Santa Paula Basin.

Natural recharge and limited draft in Santa Clara River Valley keeps the water table near the surface along most of river in Ventura County and there are only two areas at present where unoccupied capacity exists and then only during dry periods. These are in Piru Basin extending down into Fillmore Basin and in Montalvo Basin. Both of these will be fully recharged by the spreading works proposed and even with ultimate development are expected to be full to overflowing in wet cycles without spreading works.

Of all surface reservoirs, Cold Spring on Sespe Creek can be built the cheapest and would conserve 8600 acre-feet at an estimated capital cost of $224 per acre-foot, assuming that Montalvo spreading works are operated as planned.

This water would in part percolate as it flowed down Sespe Creek cone but the major part would reach the Saticoy diversion to go southward in a conduit. No attempt has been made to estimate carefully the cost per acre-foot delivered at the Saticoy diversion from Cold Spring Reservoir as compared to cost of the same delivery of water secured by pumping in Santa Paula Basin but it is believed that if legal difficulties could be equably adjusted the cost of delivering an acre-foot at the diversion by pumping an amount in Santa Paula Basin equal to the possible conservation in Cold Spring Reservoir and thereby creating storage space in Santa Paula Basin, would be probably not more than half the cost of delivering an acre-foot from the surface reservoir. The same pumping installation would make possible the extraction of more water at a smaller unit cost.

Further steps therefore depend on the situation as it is at the time necessity exists. Pumping in Santa Paula Basin will be accepted or rejected when the time arrives that more water is needed. Further steps after that development or in lieu of that development depending on the situation at the time appear to be about as follows in order of desirability: (a) Construction of Cold Spring Reservoir; (b) construction of Topa Topa Reservoir; (c) spreading of river water in

Fillmore Basin if the water table lowers; (d) construction of Camarillo Reservoir or other reservoirs in southern valleys and enlargement of the lower end of the conduit from Santa Clara River; (e) construction of Devil Canyon Reservoir on Piru Creek.

THE SILT PROBLEM

In attempting to conserve the waste water of Santa Clara River the silt carried by the stream and its tributaries will add to the cost an amount which can not be accurately evaluated and this intangible cost must be considered in any construction program. It is not considered in the foregoing estimates. Surface reservoirs will eventually be filled with silt, their usefulness gone and the investment destroyed unless they can be desilted. It is believed that the proposed spreading works are so designed that the silt can be removed and placed in a position where the normal floods will carry it into the ocean but this will add to the operating cost. Conservation by pumping from Santa Paula Basin would not encounter this problem to any greater extent than it occurs naturally. Silt if deposited would be removed without effort.

The situation appears to be as follows:

1. Pumping in Santa Paula Basin to create storage space underground and kill the willow growth which is now wasting water would not be hampered by an aggravated silt problem.

2. Spreading works which accomplish any considerable amount of salvage must be operated in floods and the silt consequently deposited in them must be removed artificially, thereby increasing operating expense.

3. No way of removing silt from surface reservoirs is known and the usefulness of any constructed must eventually be destroyed unless it can be disposed of. Some are located more favorably than others and other things being equal, if surface reservoirs are constructed the location at which the silt carried is least should be chosen first.

CHAPTER XIV

VENTURA RIVER BASIN WATER SUPPLY AND DEVELOPMENT

Ventura River drains an area of 226 square miles. It discharges into the extreme northerly end of the Coastal Plain and its waters under natural conditions do not influence the supply to the underground waters of the plain.

The principal tributaries are Coyote Creek from the west, with a drainage area of 41 square miles and San Antonio Creek from the east, with a drainage area of 51 square miles, which enter the river at the upper end of the canyon which the river has cut in the coastal range to find its way to the ocean. These two tributaries extend fan-like from the main stream and their valleys together with the river valley form a basin of plains and rolling hills entirely surrounded by mountains.

Rainfall, as shown by Plate II, page 18, averages from 19 inches to 23 inches annually and is higher than in most of the habitable portion of Ventura County. This is reflected in the more prolific growth of oaks which cover large portions of the hills and plains of the valley. The eastern arm of the valley drained by San Antonio Creek is known as Ojai Valley from the town of that name. The western end is called Santa Ana Valley from the name of the creek, while the center drained by Ventura River is called Upper Ventura River Valley.

The status of lands is shown in Table 71, page 221, and Plate C, in rear pocket.

The city of Ventura gets most of its supply by gravity and pumping at a diversion point above Casitas Road Bridge. Its production from this source is not known exactly but the entire supply from this and other sources was 3300 acre-feet in the twelve months July, 1932, to June, 1933. From this it supplied inclusive of transportation losses approximately 1400 acre-feet for domestic use in the city, 1400 acre-feet for industrial use, and 500 acre-feet to 777 acres of irrigated land along Ventura Avenue, north of the city limits.

Water Supply and Present Demand

For the Ventura River Basin all analyses of the water supply have been made for the period spring, 1922, to fall, 1932, as this encompasses the period of most deficient rainfall on which there are records. The average water crop for the period is estimated to be as follows:

TABLE 51

AVERAGE WATER CROP, VENTURA RIVER BASIN, SPRING 1922—FALL 1932

Ventura River System	18,900 acre-feet
Santa Ana Creek System	6,300 acre-feet
San Antonio Creek System	4,800 acre-feet
Total	30,000 acre-feet

Compared to this the estimated use of water is approximately as follows:

TABLE 52

USE OF WATER, VENTURA RIVER BASIN

Consumptive use—irrigation and domestic, 4,300 acres at 1.00–1.25	4,300–5,400 acre-feet
Consumptive use of Willows, etc., immediately above Casitas Road, 150 acres at 4.00	600 acre-feet
City of Ventura, approximately	3,000 acre-feet
Total	7,900–9,000 acre-feet

The remainder of 21,000–22,000 acre-feet wastes into the ocean or is consumed by vegetation below Casitas Road.

OJAI BASIN

It is in this basin that the development has been most rapid and it is here that it is to be expected to be most rapid for the near future.

Practically all water supplies are secured by pumping. Ground-water is replenished from rainfall on the valley floor and by percolation of Gridley, Senor, Horn and miscellaneous smaller creeks as they cross the large and porous detrital cones at their mouths. It is only in years of larger floods that water from these canyons is sufficient to cross the cone and reach the channel of San Antonio Creek. Rainfall on the valley floor averages about 20 inches annually and of this a considerable portion penetrates to the water table.

Development

As shown by Table 71 there are 1540 acres net now using water on both hill and valley; 2470 acres remaining in the valley which can be considered as irrigable judging from the topographic standpoint; and 620 acres classified as "irrigable or habitable" on the hills (Plate XLIX in rear pocket). The future is problematical. In the valley the climate immediately east of and adjacent to the city of Ojai has been found too cold for citrus and little attempt has been made to grow other crops. On the hills the soil is of poorer quality and the future use of the land probably lies in subdivision into estates. The cost of water would not be of moment to such holdings as in general only the area immediate to the dwelling place is irrigated. For the purpose of an estimate it is assumed that 75 per cent of the remaining valley or 1900 acres and 25 per cent of the remaining hill land or 150 acres will demand water at some future day if it is available. This amounts to assuming that all the hill land will be subdivided but only one-quarter actually irrigated.

What has been said in a previous chapter in discussing the future of valley lands not now irrigated in Santa Clara River Valley and the difficulty in reclaiming them applies even more cogently to Ojai Valley where return from citriculture is smaller.

Underground Basin

With information available no attempt has been made to estimate the change in content of the underground basin during the years of investigation. The drop in water table between fall 1927, when the depth to water was first measured, and fall 1931, the lowest level reached during the investigation, averaged 46.8 feet over the area

in which wells exist. By fall 1932 the water table had recovered 32.1 feet or 71 per cent. At elevations at and above that midway between the highest and lowest above noted water seeps out of the basin to San Antonio Creek.

Period	*Change per year*	*Average rainfall over basin*	*Per cent of long time average*
Fall 1927–fall 1931	—11.7	14.81	74
Fall 1931–fall 1932	+32.1	27.34	135

Additional capacity could be secured by pumping below the water table of fall 1931.

Water Supply

The estimated average annual run-off tributary to Ojai Valley is 5000 acre-feet for the period of deficient rainfall for which calculations are made in this report. No estimate has been made of consumptive use for irrigation or of run-off out of the valley. Average annual rainfall penetration is thought to be above 800 acre-feet.

Conclusion

It is believed that the average annual recharge of Ojai Basin is greater than present draft on it. The basin is limited in capacity and changes in water table are large during a wet or dry year. It is believed that the same formation found above the lowest recorded water table exists below it and hence that capacity to retain recharge could be increased if the water table lowered and this will come about as development increases. Leakage from the basin would be decreased if the water table lowered.

It seems probable that if spreading is done when it eventually becomes necessary the average annual recharge during a period similar to the 40-year period since 1892 would be sufficient to maintain a draft at least 50 per cent greater than present and perhaps more. The additional draft would cause much further lowering of the water table and more extreme annual fluctuations than present.

It will be perhaps many years before development will cause draft to approach available natural supply. If it passes it, spreading on the cones should be the first step in conservation and if necessary to import, Ventura River is the possible source.

SANTA ANA CREEK VALLEY

Only 170 acres are now irrigated and those by gravity. There are no underground reservoirs of sufficient capacity to furnish a supply. As shown by Table 71, page 221, there is an area of 2600 acres in the valley floors classed as irrigable topographically and 1300 acres in the hills classed as "irrigable or habitable" on Plate XLIX in pocket.

Perhaps there are small reservoir sites not discovered in this investigation in which a supply can be conserved for summer irrigation, but the amount which can be thus developed is believed negligible. It is not believed feasible to develop any other reservoir sites for irrigation and, therefore, studies have not been made. There appears little possibility of further development of irrigated agriculture but

if demand arises and if Dunshee Reservoir is built a supply might be secured from it.

UPPER VENTURA RIVER VALLEY

Ventura River after leaving the mountains has cut a channel in the alluvium considerably below the general level and about 2000 feet wide. It continues in this until it reaches the mountains below. For the first six miles the stream loses water. Below this point the river bed is still absorptive but the water table is close to the surface and water rises in the stream bed so that a dense growth of water-loving vegetation is maintained almost to the ocean. The largest single area thus occupied is immediately above Casitas Road where there are about 150 acres of willows. Present irrigated area above Casitas Road drawing on Ventura River supply is about 1000 acres in the valley and 40 acres in the hills. Below Casitas Road a total of 1320 acres is using water supplied by the city, of which 780 acres are irrigated land and 540 acres are subdivision. In the valley above Casitas Road there are 3800 acres classed as irrigable from a topographic standpoint and 2200 acres in the hills classed as "irrigable or habitable" on Plate XLVIII in rear pocket. Below Casitas Road there are in the river valley proper another 1000 acres classed as irrigable from a topographic standpoint and about 460 acres of hill land classed as "irrigable or habitable."

The greater part of the land now irrigated above Casitas Road receives its supply from gravity conduits diverting from the river and taking all the summer flow. Wells have not been successful on the mesa to the east and west of the river wash. Some pumping from the river wash has been done for lands to the west but only small areas are thus irrigated. Apparently no serious attempt has been made to secure water from this source for lands to the east.

Percolation in River Wash

During the investigation the only period when the flow of the stream continued long enough to get measurements of percolation was in 1932. The estimated average daily discharges and percolation losses are shown in parallel at various locations in Table 7, page 62. There are no wells below Meyer Road by which distance to water table can be determined, but in general it is believed that it is not at great depth.

The run-off for the season 1931–1932 was about 12 per cent above the estimated average for the forty-year period. The measurements on percolation above cited indicate that the cone soon fills with an above normal run-off.

It is believed that the yield of Ventura River Basin could be increased by pumping from ground water in the basin between Casitas Road and La Crosse and also in the basin above La Crosse. This would increase the yield (1) by depriving the water-loving vegetation of the water which it now transpires and (2) by providing space to impound the floods of the more prolific years of the dry cycles. The only present user which could pump this basin is the city of Ventura.

The following table based on interpolation between occasional measurements shows the approximate discharge of rising water above the city's intake at Casitas Road and above Coyote Creek inflow but

below San Antonio Creek compared with the city's use of water July, 1931, to June, 1932, inclusive. As the surface flow of both creeks is negligible the quantities in the table are presumed to be rising water mainly from the underground storage basin in Ventura River Valley. The city supplements its supply by pumping in the river gravels near this point. Presumably when this pumping is going on natural rising water is decreased.

No attempt is made to evaluate the total possible yield from this basin at present or if supplemented by spreading operations in the basin.

TABLE 53

APPROXIMATE AMOUNT OF RISING WATER ABOVE VENTURA CITY INTAKE

Based on Occasional Measurements

	Discharge in second-feet					Demand, second-feet
	1928	1929	1930	1931	1932	
January 1	7.5	2.0	2.5	1.0	2.0	3.4
February 1	8.5	2.5	4.0	.5	5.0	2.9
March 1	9.0	7.5	5.5	1.0	8.0	4.7
April 1	8.0	12.0	6.5	1.0	13.0	4.9
May 1	6.5	13.0	7.0	2.0	13.0	5.2
June 1	5.5	11.5	7.0	3.0	13.0	4.9
July 1	5.0	7.0	6.0	2.5	9.0	6.0
August 1	4.5	7.0	7.0	2.0	8.0	5.9
September 1	4.0	5.5	2.0	2.0	5.0	4.8
October 1	2.5	4.5	3.0	1.5	4.0	5.0
November 1	2.0	3.0	1.0	1.0	----	4.1
December 1	1.5	3.0	1.0	1.0	----	3.9

POSSIBLE DEVELOPMENT VENTURA RIVER VALLEY

The cost of Dunshee Reservoir on Coyote Creek * and Matilija Reservoir on Matilija Creek was estimated for various capacities. These are discussed in Chapter XI and a curve of total cost for various capacities is shown on Plate XXV, page 120. A curve of acre-foot cost of capacity is shown on Plate XXVI, page 122. In estimates of yield it is assumed that Santa Ana Creek is diverted to Dunshee Reservoir through the low pass on the north side by a 200 second-foot canal 1.25 miles long. The estimated cost is $35,000 and this should be added to cost of that reservoir shown on the above plates.

TABLE 54

DUNSHEE RESERVOIR

Approximate Yield and Cost, 1922-1932; Annual Draft Equal Each Year

Capacity, acre-feet	Cost*	Conservation,* acre-feet	Cost per acre-foot of conservation
2,600	$505,000	1,000	$505
5,000	610,000	1,500	407
7,400	780,000	2,000	390
9,800	1,010,000	2,500	405

* Includes diversion from Santa Ana Creek.

* Surveys of Dunshee Reservoir by other interests were available but no surveys were available for another site a short distance above the mouth of Coyote Creek. Funds were not available for the survey and no estimates were made of the cost. Its location is not shown on Frontispiece. This site should be investigated if reservoir development is planned.

Curves of estimated yield for different capacities were not drawn but the following tabulation shows approximations derived from various studies of the salvage accomplished by these reservoirs for the period 1922–1932.

TABLE 55

MATILIJA RESERVOIR

Approximate Yield and Cost, 1922-1932; Annual Draft Equal Each Year

Capacity, acre-feet	Cost	Conservation, acre-feet	Cost per acre-foot of conservation
8,100	$2,330,000	2,600	$533
10,000	2,550,000	5,300	481
14,000	3,300,000	5,800	570

The cost of a pipe line to carry 25 second-feet to Ojai Basin was also estimated, based not on a detailed survey but examination of U. S. G. S. topographic sheets and a reconnaissance of the line. This water would be spread when not needed for direct irrigation. This cost estimate given in detail on page 226 is $215,000.

City of Ventura

The city apparently does not have a full supply for present demands at its present intake in Ventura River during the late summer and fall and in dry winters. Although the gravity flow is supplemented by pumping, supply to the pumps is insufficient.

The average annual waste from Ventura River Basin in the dry period 1922–1932 is estimated at 22,000 acre-feet after supplying all demands of the city and in the valley above. Evidently there is plenty of water but the difficulty lies in making it available. The following possibilities for the city should be investigated.

1. Installation of pumps in the valley below Casitas Road or near the ocean or perhaps leasing already existing wells. No investigation was made of the possible yield from these sources or the chances of contamination by salt water intrusion from the ocean or from the oil wells.

2. Development of the Upper Ventura River Valley underground basin by wells and spreading grounds. This may involve some legal complications and the yield from it is uncertain.

3. Construction of Dunshee Reservoir or other reservoir at considerable expense.

4. Pumping in the Coastal Plain northwest of Saticoy and in the area receiving its supply from Santa Clara River. This may entail legal complications.

Lands in Upper Ventura River Valley

A certain additional development is believed possible by pumping from the gravel basin. The fact that this has not been extensively done although the water is there leads to the belief that cost and other complications have impeded it and that returns from agriculture would not justify it. If the surrounding area is subdivided into estates such a development would secure water in this way and the cost would not be prohibitive.

	Acton	No. 1 Power House***	Snyder Ranch	Conejo Ranch No. 1	Santa Susana
1892–93			20.53		
1893–94			5.45		
1894–95			13.91		
1895–96			8.44		
1896–97	11.93		18.54		
1897–98	5.83		4.26		
1898–99	4.00		7.88		
1899–00	6.50		7.81		
1900–01	14.50		13.09		
1901–02	10.68		10.41		
1902–03	15.74		17.55		
1903–04	4.62		7.82		
1904–05	17.54		20.67		
1905–06	16.04		18.57		
1906–07	21.37		23.02		
1907–08	11.49		16.01		
1908–09	12.11		23.82		
1909–10	14.99		14.97		
1910–11	12.92		20.79		
1911–12	13.80		9.43		
1912–13	9.04		11.14		
1913–14	17.80		22.02	26.36	19.79
1914–15	17.62		16.75	22.80	19.92
1915–16	14.37		17.08	16.63	16.96
1916–17	10.35		15.74	15.96	11.90
1917–18	9.25		16.81	15.99	17.99
1918–19	13.12	14.34	10.10	11.79	8.11
1919–20	13.55	17.92	9.43	11.49	10.74
1920–21	11.48	17.55	11.60	12.10	7.24
1921–22	14.74	26.44	15.91	20.02	16.30
1922–23	10.55	16.91	12.51	9.50	8.53
1923–24	9.49	8.06	6.26	7.39	5.36
1924–25	7.70	12.72	9.28	9.29	9.92
1925–26	13.18	21.64	16.68	18.75	18.25
1926–27	13.81	21.66	15.45	18.22	16.28
1927–28	6.51	13.52	9.95	10.89	12.05
1928–29	7.24	13.54	10.46	10.00	10.34
1929–30	7.78	12.46	9.83	12.02	11.16
1930–31	9.06	16.99	10.33	12.59	11.90
1931–32	16.32	25.23	15.87	17.60	15.91
Years of record	36	14	40	19	19
Mean of record	11.86	17.07	13.65	14.70	13.09
Estimated 40-year mean	11.66	17.64	13.65	14.88	13.25
Elevation above sea level	3,300	3,000	300	650	980
Station number	1	38	54	5	50

* Records from Los Angeles County Flood (
** Records from United States Weather Bur
*** Los Angeles City Water Works Departm

TABLE 56

RECORDS OF PRECIPITATION AT KEY STATIONS USED IN COMPUTING AVERAGE ANNUAL RAINFALL

Seasonal Year, July 1–June 30. Rainfall in Inches

	Santa Barbara**	*Ojai Valley**	Upper Ojai Valley	Matilija Canyon	Wheeler Springs	Mono Ranch**	Hueneme	Santa Paula	Fillmore	Newhall Ranch	Mellon Ranch*	Newhall Depot**	Acton	No. 1 Power House***	Snyder Ranch	Conejo Ranch No. 1	Santa Susana
1892–93	26 97						19 62					23 14			20 53		
1893–94	7 02						6 28					7 19			5 45		
1894–95	16 34						13 13					19 86			13 91		
1895–96	13 37						10 27					8 76			8 44		
1896–97	18 50						10 37				12 68	18 42	11 93		18 54		
1897–98	4 99						3 93	5 91			2 73	5 62	5 83		4 26		
1898–99	12 33						10 77	7 40			2 98	5 44	4 00		7 88		
1899–00	12 66						9 56	9 57			5 46	7 59	6 50		7 81		
1900–01	15 40		25 64				10 55	16 09			9 28	19 08	14 50		13 09		
1901–02	14 21		16 03			19 38	11 68	13 09			6 34	9 89	10 68		10 41		
1902–03	20 74		22 65			23 64	18 62	18 40			12 35	19 64	15 74		17 55		
1903–04	11 58		12 54	17 75		14 78	7 39	11 54			3 80	8 22	4 62		7 82		
1904–05	29 64		37 32	40 75		45 20	19 17	24 26			13 31	27 53	17 54		20 67		
1905–06	22 70	23 71	25 53	26 87		38 99	16 27	17 93	19 81		12 37	18 39	16 04		18 57		
1906–07	27 72	37 44	42 38	41 00		53 36	23 92	27 83	27 52		15 97	33 06	21 37		23 02		
1907–08	19 21	18 95	21 17	20 25		27 18	15 11	14 58	15 55		9 09	15 31	11 49		16 01		
1908–09	36 29	29 24	33 70	35 55		40 80	19 93	25 90	26 45		8 08	22 63	12 11		23 82		
1909–10	19 62	19 64	16 32	30 86		24 38	13 17	13 94	17 48		9 66	19 85	14 99		14 97		
1910–11	31 94	33 91	33 01	45 48		55 82	17 83	22 00	25 25		10 48	22 72	12 92		20 79		
1911–12	16 35	13 34				20 02	9 51	11 14	12 12		7 65	20 03	13 80		9 43		
1912–13	12 58	18 12	19 71	19 00		22 92	11 62	14 91	16 15	13 78	5 09	17 79	9 04		11 14		
1913–14	31 52	39 60	46 26	50 75		58 72	17 95	28 98	32 99		14 09	31 24	17 80		22 02	26 36	19 79
1914–15	21 25	24 02	27 03	27 50			18 52	23 12	23 13	19 96	12 65	27 50	17 62		16 75	22 80	19 92
1915–16	25 90	28 30	26 23	33 87			17 53	23 05	24 99	20 50	10 49		14 37		17 08	16 63	16 96
1916–17	22 56	22 15	19 36	25 27			17 08	21 39	21 12	12 49	5 95		10 35		15 74	15 96	11 90
1917–18	21 68	24 99	29 05	28 00			16 98	19 84	19 94	18 06	8 20		9 25		16 81	15 99	17 99
1918–19	14 46	13 55	14 62				9 67	12 41	11 33	12 10	8 61	11 31	13 12	14 34	10 10	11 79	8 11
1919–20	14 68	16 64	16 22	16 88			8 30	14 24	15 17	14 02	9 84	14 51	13 55	17 92	9 43	11 49	10 74
1920–21	14 31	18 30	17 98	17 37			11 42	17 28	18 72	14 06	8 89	21 71	11 48	17 55	11 60	12 10	7 24
1921–22	19 22	26 91	29 56	33 25			14 81	21 10	22 81	21 31	14 49	31 15	14 74	26 44	15 91	20 02	16 30
1922–23	17 24	18 83	17 05	21 77			10 24	14 93	16 53	13 23	6 68	11 22	10 55	16 91	12 51	9 50	8 53
1923–24	6 36	7 30	7 13	9 49			5 78	7 71	7 28	7 99	6 26	8 01	9 49	8 06	6 26	7 39	5 36
1924–25	12 26	11 96	11 36	12 67	14 34		8 04	10 01	10 52	8 47	7 64	7 49	7 70	12 72	9 28	9 29	9 92
1925–26	16 87	21 70	19 71	32 04	38 20		15 24	16 41	20 34	18 78	11 01	25 53	13 18	21 64	16 68	18 75	18 25
1926–27	22 68	26 19	26 31	33 07			16 68	23 32	23 24	17 57	11 89	23 66	13 81	21 66	15 45	18 22	16 28
1927–28	13 54	15 66	13 31	14 74	17 80		9 07	11 15	11 35	9 80	4 80	10 46	6 51	13 52	9 95	10 89	12 05
1928–29	14 54	13 14	14 29	19 28	20 03		9 18	13 48	16 10	12 24	5 96	12 70	7 24	13 54	10 46	10 00	10 34
1929–30	13 71	13 99	15 45	16 75	18 31		10 03	12 26	14 57	14 60	9 86	11 19	7 78	12 46	9 83	12 02	11 16
1930–31	14 55	16 62	16 63	16 94	17 91		11 31	14 00	14 69	12 89	10 26	14 07	9 06	16 99	10 33	12 59	11 90
1931–32	22 13	26 11	28 83	30 05	30 96	36 11	16 05	20 60	23 19	21 37	15 58	25 47	16 32	25 23	15 87	17 60	15 91
Years of record	65	27	31	27	7	14	40	35	27	19	36	37	36	14	40	19	19
Mean of record	18 10	21 49	22 65	26 56	22 51	34 38	13 31	16 56	18 83	14 91	9 18	17 23	11 86	17 07	13 65	14 70	13 09
Estimated 40-year mean	18 24	20 14	21 06	24 48	27 30	28 11	13 31	16 56	17 94	15 59	9 02	17 28	11 66	17 64	13 65	14 88	13 25
Elevation above sea level	125	800	1,250	950	1,560	3,210	10	275	530	750	3,100	1,273	3,300	3,000	300	650	980
Station number	46	30	64	107	70	21	17	48	11	25	74	28	1	38	54	5	50

* Records from Los Angeles County Flood Control District.
** Records from United States Weather Bureau.
*** Los Angeles City Water Works Department.

TABLE 57

SUMMARY OF DETAIL CALCULATIONS OF RAINFALL PENETRATION IN INCHES[a]

Basin	Seasonal rainfall	Penetration below root zone															
		Citrus				Deciduous		Beans			Grain		Truck, miscellaneous, garden, alfalfa	Bare land	Grass and weeds	Brush
		Clean cultivated		Cover cropped		Clean cultivated	Cover cropped	Irrigated		Non-irrigated	Fall planted					
		Irrigated		Irrigated												
		Just prior to rains	Usual practice	Just prior to rains	Usual practice			Clean cultivated after crop	Planted to truck after crop, also beets alone	Clean cultivated after crop	Irrigated	Non-irrigated				
FOR 1927-28																	
Piru	10.44	1.4	0	1.4	0	0	0	1.9	0	0	0.2	0	0	2.9	0	0
Fillmore	11.57	0.9	0	0.9	0	0	0	2.0	0	0.2	0	0	0	3.0	0	0
Santa Paula	9.71	0.7	0	0.7	0	0	0	1.3	0	0	0	0	0	2.3	0	0
Montalvo, north of river[b]	9.92	0.9	0	0.9	0	0	0	1.0	0	0	0.3	0	0	2.0	0	0
Montalvo, south of river[b]	9.36	1.1	0	1.1	0	0	0	0.6	0	0	0.3	0	0	1.5	0	0
West Las Posas	9.90	1.1	0	1.1	0	0	0	0.6	0	0	0.3	0	0	1.5	0	0
Pleasant Valley[b]	9.98	0.6	0	0.6	0	0	0	0.2	0	0	0	0	0	1.1	0	0
Las Posas (Moorpark)	10.03	1.5	0	1.5	0	0	0	0.7	0	0	0	0	0	1.7	0	0
Conejo (Santa Rosa)	[c]10.95	0.8	0	0.8	0	0	0	1.3	0	0.2	0	0	0	2.3	0	0
Simi	11.93	1.1	0	1.1	0	0	0	2.5	0	0.5	0	0	0	3.5	0	0
Ojai Valley	[d]14.36	3.1	1.1	1.6	0	0	0	4.8	1.8	2.8	2.8	0	0.6	5.8	0	0
Ventura River	14.36	3.1	1.1	1.6	0	0	0	4.8	1.8	2.8	2.8	0	0.6	5.8	0	0
Ventura Avenue	13.09	2.3	0.5	1.6	0	0	0	2.9	1.0	0.9	2.0	0	0.3	3.9	0	0
FOR 1928-29																	
Piru	11.97	1.8	0	1.5	0	0	0	3.0	0.3	1.3	1.3	0	0	4.0	0	0
Fillmore	15.42	3.9	1.9	2.0	0.1	0.2	0	5.9	1.9	3.9	2.9	0	1.4	6.9	0	0
Santa Paula	12.72	1.2	0	1.0	0	0	0	3.3	0.1	1.3	1.2	0	0	4.3	0	0
Montalvo, north of river[b]	11.06	0.2	0	0.2	0	0.3	0	2.0	0	0.1	0.1	0	0	3.0	0	0
Montalvo, south of river[b]	10.69	0.3	0	0.2	0	0.8	0	1.7	0	0.1	0.1	0	0	2.7	0	0
West Las Posas	12.27	0.3	0	0.2	0	0.6	0	1.7	0	0.1	0.1	0	0	2.7	0	0
Pleasant Valley[b]	10.34	0.4	0	0.1	0	0	0	1.5	0	0	0	0	0	2.5	0	0
Las Posas (Moorpark)	10.39	0.1	0	0	0	0	0	1.9	0	0	0	0	0	2.9	0	0
Conejo (Santa Rosa)	[c]11.09	0.7	0	0.7	0	0	0	2.2	0	0	0.5	0	0	3.2	0	0
Simi	11.84	1.1	0.1	0.7	0	0	0	2.9	0.1	1.2	1.1	0	0	3.9	0	0
Ojai Valley	12.97	1.7	0	1.3	0	0	0	3.6	0.1	1.6	1.1	0	0	4.6	0	0
Ventura River	14.72	3.5	1.5	1.8	0	0	0	5.5	1.9	3.5	2.9	0	1.0	6.5	0	0
Ventura Avenue	12.28	2.2	0.7	1.2	0	0	0	3.3	0.9	1.3	1.9	0	0.5	4.3	0	0

TABLE 57—Continued

SUMMARY OF DETAIL CALCULATIONS OF RAINFALL PENETRATION IN INCHES[a]

Basin	Seasonal rainfall	Penetration below root zone														
		Citrus				Deciduous		Beans			Grain		Truck, miscellaneous, garden, alfalfa	Bare land	Grass and weeds	Brush
		Clean cultivated		Cover cropped		Clean cultivated	Cover cropped	Irrigated		Non-irrigated	Fall planted					
		Irrigated		Irrigated				Clean cultivated after crop	Planted to truck after crop, also beets alone	Clean cultivated after crop	Irrigated	Non-irrigated				
		Just prior to rains	Usual practice	Just prior to rains	Usual practice											
FOR 1929-30																
Piru	13.58	5.0	3.0	2.8	0.8	0	0	4.1	1.2	2.1	2.2	0.4	2.5	5.1	0	0
Fillmore	13.68	5.3	3.3	3.2	1.2	0	0	4.9	1.8	2.9	2.8	0.8	2.8	5.9	0	0
Santa Paula	11.32	3.5	1.5	2.3	0.2	0	0	3.0	0.2	1.0	0.9	0	1.0	4.0	0	0
Montalvo, north of river[b]	10.97	3.2	1.2	2.1	0.1	0	0	2.7	0	0.7	0.7	0	0.7	3.7	0	0
Montalvo, south of river[b]	10.44	2.8	0.8	1.7	0	0	0	2.2	0.2	0.4	0.3	0	0.3	3.2	0	0
West Las Posas	11.33	3.4	1.4	2.2	0.3	0	0	2.8	0.3	1.0	0.9	0	0.9	3.7	0	0
Pleasant Valley[b]	9.96	2.2	0.2	1.2	0	0	0	1.4	0	0	0	0	0	2.4	0	0
Las Posas (Moorpark)	10.14	2.7	0.7	1.6	0.1	0	0	2.0	0	0	0	0	0.3	3.0	0	0
Conejo (Santa Rosa)	9.87	1.9	0	0.8	0	0	0	1.4	0	0	0	0	0	2.4	0	0
Simi	11.31	2.5	0.5	1.2	0	0	0	2.0	0	0	0	0	0	3.0	0	0
Ojai Valley	13.43	5.5	3.5	1.9	1.2	0	0	5.0	2.0	3.0	3.0	0.7	3.0	6.0	0	0
Ventura River	11.93	4.3	2.4	2.1	0.5	0	0	3.8	0.8	1.8	1.8	0	1.9	4.8	0	0
Ventura Avenue	11.24	3.6	1.6	2.0	0.2	0	0	2.9	0	0.9	0.9	0	1.1	3.9	0	0
FOR 1930-31																
Piru	12.94	3.5	2.8	1.3	1.3	0	0	3.8	1.3	1.8	2.3	0	2.3	4.8	0	0
Fillmore	15.05	4.6	4.0	2.0	1.9	0.1	0	5.6	2.1	3.6	3.1	0	3.5	6.6	0	0
Santa Paula	13.54	2.1	1.1	0.2	0	0	0	3.8	0.5	1.8	1.5	0	0.6	4.8	0	0
Montalvo, north of river[b]	13.23	1.0	0	0.1	0	0	0	3.2	0	1.2	0.9	0	0	4.2	0	0
Montalvo, south of river[b]	11.46	1.1	0.5	0	0	0	0	2.1	0	0.6	0.3	0	0	3.1	0	0
West Las Posas	11.05	0.9	0.5	0	0	1.2	0	1.6	0	0.3	0.1	0	0	2.6	0	0
Pleasant Valley[b]	9.86	2.2	2.2	0.2	0.2	0	0	1.0	0	0	0	0	1.8	2.0	0	0
Las Posas (Moorpark)	10.46	2.1	2.1	0.2	0.2	0	0	1.9	0	0	0	0	1.8	2.9	0	0
Conejo (Santa Rosa)	12.24	2.1	2.1	0.2	0.2	0	0	2.6	0	0.6	0	0	1.8	3.6	0	0
Simi	12.35	1.8	1.1	1.3	0	0	0	3.3	0.1	1.2	1.0	0	0.6	4.3	0	0
Ojai Valley	15.63	3.2	1.2	1.2	0	0	0	5.1	1.4	3.1	2.4	0	0.7	6.1	0	0
Ventura River	15.70	3.5	1.5	1.5	0	0.2	0	5.3	1.8	3.3	2.8	0	1.0	6.3	0	0
Ventura Avenue	14.23	2.5	0.7	0.7	0	0	0	4.0	0.9	2.0	1.9	0	0.5	5.0	0	0
FOR 1931-32																
Piru	20.95	9.2	7.2	7.2	5.2	3.8	1.8	9.8	7.8	7.8	8.8	4.8	6.8	10.8	1.5	0.1
Fillmore	21.71	10.2	8.2	8.2	6.2	4.7	2.7	10.7	8.7	8.7	9.7	5.7	7.7	11.7	2.9	0.7
Santa Paula	18.68	7.9	5.9	6.0	4.0	2.5	0.8	8.4	6.4	6.4	7.4	3.4	5.4	9.4	1.2	0
Montalvo, north of river[b]	16.86	6.1	4.2	4.8	2.6	0.8	0	6.7	4.7	4.7	5.7	1.7	3.7	7.7	0	0
Montalvo, south of river[b]	15.86	5.4	3.4	4.1	2.1	0.3	0	5.9	3.9	3.9	4.9	0.9	2.9	6.9	0	0
West Las Posas	15.82	5.0	3.0	3.5	1.5	0.1	0	5.5	3.5	3.5	4.5	0.5	2.5	6.5	0	0
Pleasant Valley[b]	14.78	4.4	2.5	2.7	0.8	0	0	5.0	3.0	3.0	4.0	0	2.0	6.0	0	0
Las Posas (Moorpark)	15.80	4.7	2.7	2.9	0.9	0	0	5.2	3.2	3.2	4.2	0.4	2.2	6.2	0	0
Conejo (Santa Rosa)	13.54	3.4	1.4	1.6	0	0	0	3.9	1.9	1.9	2.9	0	0.9	4.9	0	0
Simi	16.78	5.0	3.0	3.0	1.0	0	0	5.5	3.5	3.5	4.5	0.5	2.5	6.5	0	0
Ojai Valley[e]	25.81	13.0	11.0	11.0	9.0	7.5	5.5	13.5	11.5	11.5	12.5	8.5	10.5	14.5	5.8	4.2
Ventura River[e]	26.29	14.9	12.9	12.9	10.9	9.4	7.4	15.4	13.4	13.4	14.4	10.4	12.4	16.4	7.8	5.8
Ventura Avenue	22.30	11.4	9.4	9.4	7.4	5.9	3.9	11.9	9.9	9.9	10.9	6.9	8.9	12.9	4.3	2.9

[a] Computed by the Division of Water Resources from data in this chapter and other information.
[b] In non-pressure area.
[c] An average of Pleasant Valley and Simi.
[d] No record—used Ojai values.
[e] These figures do not allow for run-off from rainfall, which is estimated to be 1.4 inches for Ojai Valley and 1.6 inches for Ventura River. Estimate based on run-off records.

TABLE 58

SANTA CLARA RIVER—ESTIMATED RAINFALL PENETRATION IN ACRE-FEET OF SANTA CLARA RIVER VALLEY AREA AND NON-PRESSURE AREA, OXNARD PLAIN

For 40-year Period, 1892–93 to 1931–32

Season	Piru Basin	Fillmore Basin	Santa Paula Basin	Montalvo Basin		West Las Posas Basin	Summation
				South	North		
1892–93	10,000	18,500	10,300	7,100	3,800	4,600	54,300
1893–94	200	100	100	0	0	0	400
1894–95	3,200	6,000	3,500	2,200	900	1,500	17,300
1895–96	1,300	1,500	900	500	200	300	4,700
1896–97	6,600	11,500	6,500	4,600	2,000	2,700	33,900
1897–98	0	100	0	0	0	0	100
1898–99	800	700	400	200	0	0	2,100
1899–00	800	800	500	200	100	100	2,500
1900–01	2,400	3,500	1,900	1,300	500	900	10,500
1901–02	2,000	2,800	1,500	1,000	400	700	8,400
1902–03	5,800	10,200	5,600	4,000	1,700	2,500	29,800
1903–04	1,000	1,000	500	300	100	100	3,000
1904–05	9,400	17,100	9,600	6,500	3,400	4,300	50,300
1905–06	5,600	9,600	5,500	3,800	1,600	2,400	28,500
1906–07	11,300	21,200	11,800	8,000	4,500	5,400	62,200
1907–08	3,500	5,800	3,200	2,100	800	1,400	16,800
1908–09	11,200	21,000	11,800	7,900	4,400	5,300	61,600
1909–10	3,000	4,700	2,600	1,800	700	1,200	14,000
1910–11	9,200	16,900	9,500	6,400	3,300	4,200	49,500
1911–12	1,300	1,500	900	500	200	300	4,700
1912–13	2,600	3,600	2,000	1,400	600	1,000	11,200
1913–14	10,600	20,100	11,300	7,500	4,200	5,100	58,800
1914–15	7,400	13,000	7,400	5,200	2,400	3,300	38,700
1915–16	7,300	12,700	7,200	5,100	2,400	3,200	37,900
1916–17	5,100	8,700	4,900	3,400	1,400	2,200	25,700
1917–18	5,300	9,300	5,200	3,600	1,500	2,300	27,200
1918–19	1,200	1,400	900	500	200	300	4,500
1919–20	1,600	2,000	1,100	700	300	400	6,100
1920–21	2,600	3,800	2,200	1,400	600	1,000	11,600
1921–22	6,000	10,300	5,800	4,100	1,800	2,600	30,600
1922–23	2,000	3,000	1,300	1,000	400	700	8,400
1923–24	100	200	100	0	0	0	400
1924–25	800	900	400	200	100	200	2,600
1925–26	4,500	8,400	3,600	2,900	1,200	2,000	22,600
1926–27	6,300	11,000	6,100	4,300	1,900	2,800	32,400
1927–28	900	900	300	300	200	100	2,700
1928–29	1,200	2,700	700	700	300	400	6,000
1929–30	1,800	2,600	1,000	900	500	600	7,400
1930–31	1,700	3,000	1,000	800	500	500	7,500
1931–32	5,100	8,300	4,800	3,300	1,700	1,900	25,100

TABLE 59

SANTA CLARA RIVER

Estimated Water Supply of Santa Clara River and Tributaries, Showing Net Input to Underground Basins, for 40-year Period, 1892–93 to 1931–32

Acre-feet

Season	Santa Clara River Valley below county line													
	Santa Clara River at Newhall Ranch bridge	Piru Creek at Piru	Hooper Creek at highway bridge	Sespe Creek at highway bridge	Santa Paula Creek at gage	Total	Sespe Creek diversions and percolation above gage	Total rainfall penetration	Santa Clara River: Valley floor run-off	Santa Clara River: Marginal area	Total	Total inflow	Outflow at Montalvo	Input to underground basins
1892–93	25,400	115,000	10,900	198,000	31,100	380,400	9,000	54,300	7,000	33,100	103,400	483,800	------	------
1893–94	12,000	2,300	200	6,500	1,000	21,800	3,000	400	2,000	1,400	6,800	28,600	13,600	15,000
1894–95	21,300	32,300	2,300	67,000	7,900	130,800	7,000	17,300	4,700	14,300	43,300	174,100	93,400	80,700
1895–96	14,000	18,400	800	31,000	4,100	68,300	6,000	4,700	3,300	5,000	19,000	87,300	38,900	48,400
1896–97	23,700	43,700	5,500	94,000	12,300	179,200	8,000	33,900	5,600	29,300	76,800	256,000	144,000	112,000
1897–98	12,300	1,300	100	1,400	300	15,400	1,400	100	1,700	1,000	4,200	19,600	7,200	12,400
1898–99	11,000	4,600	500	8,500	2,300	26,900	3,100	2,100	2,800	3,500	11,500	38,400	4,600	33,800
1899–00	13,300	7,200	600	12,500	3,000	36,600	4,000	2,500	2,900	3,700	13,100	49,700	2,300	47,400
1900–01	20,300	21,900	1,500	40,000	13,100	96,800	5,900	10,500	4,100	9,000	29,500	126,300	49,400	76,900
1901–02	16,000	9,200	1,200	16,000	4,800	47,200	4,100	8,400	3,800	7,700	24,000	71,200	9,200	62,000
1902–03	22,000	30,000	4,600	60,000	13,300	129,900	6,600	29,800	5,600	25,500	67,500	197,400	91,300	106,100
1903–04	13,000	7,600	600	13,000	3,100	37,300	4,200	3,000	3,000	3,900	14,100	51,400	10,500	40,900
1904–05	60,300	175,000	9,300	262,000	39,000	545,600	9,000	50,300	6,800	43,600	109,700	655,300	466,100	189,200
1905–06	23,700	50,600	4,300	108,000	19,300	205,900	8,000	28,500	5,800	23,600	65,900	271,800	187,500	84,300
1906–07	114,000	169,000	12,000	256,000	46,800	597,800	9,000	62,200	7,400	56,200	134,800	732,600	601,900	130,700
1907–08	19,700	27,700	2,200	57,500	11,200	118,300	7,000	16,800	4,600	13,100	41,500	159,800	97,200	62,600
1908–09	21,300	178,000	11,800	265,000	35,500	511,600	9,000	61,600	7,400	55,200	133,200	644,800	517,900	126,900
1909–10	24,000	33,400	1,800	70,000	10,800	140,000	6,800	14,000	4,400	11,000	36,200	176,200	115,400	60,800
1910–11	23,700	248,000	9,100	333,000	39,000	652,800	9,000	49,500	6,700	41,900	107,100	759,900	640,900	119,000
1911–12	20,300	28,500	800	48,300	11,000	108,900	7,000	4,700	3,300	5,000	20,000	128,900	73,400	55,500
1912–13	16,300	47,100	1,500	87,700	12,400	165,000	7,200	11,200	4,100	9,400	31,900	196,900	121,500	75,400
1913–14	92,000	251,000	11,300	337,000	53,400	744,700	9,000	58,800	7,200	53,300	128,300	873,000	737,200	135,800
1914–15	50,000	57,600	6,600	121,000	20,400	255,600	8,000	38,700	6,100	33,800	86,600	342,200	246,500	95,700
1915–16	24,300	76,400	6,400	141,000	26,400	274,500	9,000	37,900	6,100	32,800	85,800	360,300	266,700	93,600
1916–17	19,300	31,900	3,700	53,000	12,600	120,500	7,700	25,700	5,300	21,400	60,100	180,600	105,100	75,500

1917-18	18,700	80,100	4,000	146,000	27,400	276,200	10,000	27,200	5,400	22,800	65,400	341,600	249,200	92,400
1918-19	17,000	15,000	700	25,500	3,400	61,600	5,300	4,500	3,200	4,900	17,900	79,500	33,800	45,700
1919-20	18,000	19,900	1,000	30,800	7,600	77,300	5,400	6,100	3,500	6,200	21,200	98,500	47,600	50,900
1920-21	18,700	15,400	1,600	23,300	6,500	65,500	5,500	11,600	4,100	9,800	31,000	96,500	30,800	65,700
1921-22	50,300	123,000	4,800	231,000	41,900	451,000	10,000	30,600	5,600	26,000	72,200	523,200	379,900	143,300
1922-23	17,700	18,400	1,200	28,700	7,800	73,800	5,700	8,400	3,800	7,700	25,600	99,400	50,000	49,400
1923-24	14,700	3,400	200	3,300	1,800	23,400	2,400	400	2,000	1,500	6,300	29,700	9,900	19,800
1924-25	15,000	3,800	600	4,000	1,800	25,200	2,700	2,600	2,900	3,700	11,900	37,100	5,500	31,600
1925-26	26,300	44,900	3,100	81,000	15,700	171,000	6,100	22,600	5,100	18,700	52,500	223,500	126,300	97,200
1926-27	29,000	42,600	5,200	94,000	22,000	186,800	8,000	32,400	5,800	28,200	74,400	261,200	148,000	113,200
1927-28	19,600	10,800	800	16,800	3,500	51,500	4,900	2,700	3,200	4,800	15,600	67,100	20,100	47,000
1928-29	17,500	9,900	1,000	16,700	3,700	48,800	4,600	6,000	3,500	6,100	20,200	69,000	22,800	46,200
1929-30	14,500	9,400	900	15,500	3,200	43,500	4,500	7,400	3,600	6,300	21,800	65,300	17,900	47,400
1930-31	14,200	12,700	1,300	14,300	3,600	46,100	4,200	7,500	3,900	8,100	23,700	69,800	15,800	54,000
1931-32	21,200	53,000	5,100	80,200	20,700	183,200	8,200	25,100	5,700	27,400	66,400	249,600	133,000	116,600
40-year mean	25,600	53,200	3,500	87,500	15,100	184,900	6,400	20,500	4,600	18,000	49,500	234,400	----------	----------
39-year mean	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	228,000	152,100	75,900

TABLE 60

PIRU CREEK

Estimated Run-off at Proposed Reservoir Sites in Acre-feet; 40-year Period, 1892–93 to 1931–32

Year	Los Alamos Reservoir drainage area, 269 square miles	Spring Creek Reservoir drainage area, 302 square miles	Blue Point Reservoir drainage area, 367 square miles	Devil Canyon Reservoir drainage area, 389 square miles	Piru Creek Gaging Station near mouth drainage area, 432 square miles
1892–93	47,600	59,500	96,300	103,200	115,000
1893–94	900	1,200	1,900	2,100	2,300
1894–95	13,300	16,700	27,000	28,900	32,300
1895–96	7,600	9,500	15,400	16,500	18,400
1896–97	18,000	22,600	36,500	39,200	43,700
1897–98	500	700	1,100	1,200	1,300
1898–99	1,900	2,400	3,800	4,100	4,600
1899–00	3,000	3,700	6,000	6,400	7,200
1900–01	9,000	11,300	18,300	19,600	21,900
1901–02	3,800	4,700	7,700	8,200	9,200
1902–03	12,400	15,500	25,100	26,900	30,000
1903–04	3,100	3,900	6,400	6,800	7,600
1904–05	72,400	90,600	146,500	157,000	175,000
1905–06	20,900	26,200	42,300	45,300	50,600
1906–07	69,800	87,300	141,200	151,300	169,000
1907–08	11,400	14,300	23,200	24,800	27,700
1908–09	73,700	92,300	149,200	159,900	178,000
1909–10	13,800	17,300	27,900	29,900	33,400
1910–11	102,300	128,100	207,100	221,900	248,000
1911–12	11,800	14,700	23,800	25,500	28,500
1912–13	19,400	24,300	39,400	42,200	47,100
1913–14	103,700	129,900	210,000	225,100	251,000
1914–15	23,800	29,800	48,200	51,600	57,600
1915–16	31,600	39,500	63,900	68,400	76,400
1916–17	13,200	16,500	26,700	28,600	31,900
1917–18	33,100	41,400	67,000	71,800	80,100
1918–19	6,200	7,700	12,500	13,400	15,000
1919–20	8,000	10,000	16,100	17,300	19,900
1920–21	6,400	8,000	12,900	13,800	15,400
1921–22	51,000	63,800	103,200	110,600	123,000
1922–23	7,600	9,500	15,400	16,500	18,400
1923–24	1,400	1,800	2,800	3,000	3,400
1924–25	1,600	2,000	3,200	3,400	3,800
1925–26	18,500	23,200	37,500	40,200	44,900
1926–27	17,600	22,000	35,600	38,200	42,600
1927–28	4,500	5,600	9,000	9,700	10,800
1928–29	4,100	5,100	8,300	8,900	9,910
1929–30	3,900	4,900	7,900	8,500	9,440
1930–31	5,200	6,600	10,600	11,400	12,700
1931–32	21,900	27,400	44,300	47,500	53,000
Mean	22,000	27,500	44,500	47,720	53,200

Estimated from ratio of area of each watershed and rainfall on each watershed, to area and rainfall of total watershed and run-off from total watershed at Piru Gaging Station.

TABLE 61

SESPE CREEK

Estimated Run-off at Proposed Reservoir Sites in Acre-feet, 40-year Period, 1892–93 to 1931–32

Year	Cold Springs Reservoir drainage area, 65 square miles	Topa Topa Reservoir drainage area, 165 square miles	Sespe Creek Gaging Station, near mouth 257 square miles
1892–93	56,100	135,800	207,000
1893–94	2,600	6,200	9,500
1894–95	20,100	48,500	74,000
1895–96	10,000	24,300	37,000
1896–97	27,500	66,600	101,500
1897–98	800	1,800	2,800
1898–99	3,100	7,600	11,600
1899–00	4,500	10,800	16,500
1900–01	12,400	30,100	45,900
1901–02	5,400	13,200	20,100
1902–03	18,100	43,700	66,600
1903–04	4,700	11,300	17,200
1904–05	73,400	177,600	270,700
1905–06	31,500	76,400	116,400
1906–07	71,700	173,500	264,500
1907–08	17,500	42,300	64,500
1908–09	74,300	179,800	274,100
1909–10	20,800	50,400	76,800
1910–11	92,700	224,300	342,000
1911–12	13,800	33,400	50,900
1912–13	24,500	59,200	90,300
1913–14	93,800	227,000	346,000
1914–15	34,900	84,500	128,800
1915–16	40,500	98,100	149,600
1916–17	16,500	39,800	60,700
1917–18	42,400	102,700	156,600
1918–19	8,300	20,200	30,800
1919–20	9,800	23,700	36,200
1920–21	7,800	18,900	28,800
1921–22	65,500	158,500	241,600
1922–23	9,300	22,600	34,400
1923–24	1,500	3,700	5,700
1924–25	1,800	4,400	6,700
1925–26	23,600	57,100	87,100
1926–27	27,500	66,600	101,500
1927–28	5,300	12,800	19,500
1928–29	5,100	12,400	18,900
1929–30	4,900	11,800	18,000
1930–31	4,600	11,100	16,900
1931–32	22,500	54,500	83,000
Mean	25,300	61,200	93,300

Estimated from ratio of area of each watershed and rainfall on each watershed, to area and rainfall of total watershed and run-off from total watershed at Sespe Creek Gaging Station.

TABLE 62

MONTHLY RUN-OFF IN PER CENT OF SEASONAL TOTAL

Used in the Distribution of Run-off of All Santa Clara River Tributaries

Season	October	November	December	January	February	March	April	May	June	July	August	September
1892-93	.5	.6	7.9	19.5	22.9	26.1	8.2	7.9	3.9	1.9	.2	[c].4
1893-94	5.0	5.9	8.5	14.4	12.8	17.4	13.0	8.6	7.1	2.2	2.9	[c]2.2
1894-95	.6	.5	6.9	13.2	21.0	43.0	7.8	4.1	1.6	.6	1	[c].6
1895-96	2.6	12.3	13.4	3.2	12.7	39.0	9.6	3.9	1.2	.6	.8	[b].7
1896-97	.6	.3	.5	2.2	27.5	38.7	22.3	5.4	1.2	.6	.4	[b].3
1897-98	37.4	4.7	3.9	15.4	15.4	5.1	4.5	10.2	1.5	.7	.4	[b].8
1898-99	5.7	6.2	11.8	17.0	12.6	25.8	11.4	4.5	2.3	.6	1.5	[b].6
1899-00	5.7	8.1	14.6	25.8	6.2	6.2	4.4	24.2	3.3	.7	.4	[b].4
1900-01	.1	17.0	.5	10.8	51.9	12.0	2.6	3.2	1.0	.4	.3	[b].2
1901-02	2.2	10.6	2.7	8.3	13.4	36.0	17.7	6.1	1.6	.7	.4	[b].3
1902-03	.2	.3	.6	4.3	2.0	23.3	56.4	10.0	1.8	.5	.3	[b].3
1903-04	1.6	1.7	1.6	4.1	14.8	37.1	21.8	13.4	1.8	.8	.7	[b].6
1904-05	.1	.1	.2	.4	19.3	61.0	9.6	6.4	1.4	.8	.4	[b].3
1905-06	.2	.3	.2	.6	.7	69.6	19.0	4.8	2.8	1.1	.4	[b].3
1906-07	.2	.2	.8	17.1	14.4	46.6	16.4	2.1	1.2	.5	.3	[b].2
1907-08	4.0	4.0	1.9	22.4	32.3	16.7	9.6	5.1	1.9	.8	.7	[b].6
1908-09	.3	.3	.4	18.6	44.8	13.4	15.6	4.0	1.4	.6	.3	[b].3
1909-10	.4	.8	23.8	62.5	5.1	2.8	2.2	.9	.6	.4	.3	[b].2
1910-11	.2	.2	.2	14.3	19.5	55.0	6.9	2.1	.7	.4	.3	[b].2
1911-12	1.8	1.8	2.5	2.1	1.2	51.8	29.1	6.5	1.8	.6	.4	[a].4
1912-13	.2	.2	.3	7.1	69.0	14.8	4.7	2.0	1.0	.3	.2	[a].2
1913-14	.1	.3	.3	23.3	54.0	15.8	2.9	1.7	.7	.4	.3	[b].2
1914-15	.5	.4	1.5	4.5	38.6	16.3	11.6	19.1	4.6	1.6	.7	[b].6
1915-16	.9	.9	1.3	64.6	13.4	9.5	3.7	1.9	1.2	1.0	.8	[a].8
1916-17	3.8	2.6	12.7	17.3	34.8	13.7	7.6	3.9	1.6	.8	.7	[a].5

1917-18	.2	.2	.3	.3	23.7	57.9	7.1	3.9	2.7	2.0	.8	[a].9
1918-19	9.0	10.8	16.6	4.2	17.4	17.0	16.0	5.6	1.5	.8	.5	[b].6
1919-20	1.1	1.1	3.6	2.2	14.6	48.4	18.3	5.8	2.2	1.1	.8	[a].8
1920-21	1.0	2.1	2.8	15.6	14.6	25.0	8.7	19.1	6.6	1.7	1.4	[a]1.4
1921-22	.1	.1	33.6	11.3	27.9	15.4	5.7	3.5	1.4	.5	.3	[a].2
1922-23	2.6	5.2	34.6	12.5	13.4	10.5	11.6	4.6	2.6	.9	.9	[a].6
1923-24	3.5	5.3	8.8	10.5	8.8	24.5	22.8	8.8	1.7	1.8	1.7	[a]1.8
1924-25	3.0	3.0	3.0	4.5	7.4	13.4	46.3	8.9	4.5	3.0	1.5	[a]1.5
1925-26	.2	.2	.3	.5	10.1	1.8	80.4	3.8	1.4	0.6	.4	[a].3
1926-27	.3	4.0	1.4	1.1	61.3	15.8	10.4	3.0	1.3	.6	.5	[b].4
1927-28	1.7	3.8	9.3	7.3	34.2	26.5	8.0	3.9	2.1	1.3	1.0	[a].9
1928-29	1.1	2.6	8.0	8.3	20.0	23.5	24.2	5.9	2.8	1.4	1.2	[a]1.0
1929-30	1.0	1.1	1.4	12.4	5.0	51.9	12.5	8.4	3.2	1.4	0.9	[a]0.8
1930-31	1.1	1.4	1.6	6.8	47.8	6.6	14.6	12.0	4.3	1.4	1.3	[a]1.1
1931-32	.2	1.1	14.9	6.7	62.5	7.3	3.5	2.0	.8	.4	.3	[a].3

[a] Measured flow of Sespe Creek in per cent of seasonal total.
[b] Estimated from measured flow San Gabriel River. Plate 000.
[c] Estimated by rainfall concentration.

TABLE 63

ESTIMATED COMBINED MONTHLY RUN-OFF, IN ACRE-FEET, OF SANTA CLARA RIVER AND CANALS AT NEWHALL RANCH RIDGE

STATION No. 1-W

Season	October	November	December	January	February	March	April	May	June	July	August	September	Total
1892-93	1,100	1,200	2,300	3,800	4,400	4,700	2,000	2,000	1,200	1,000	800	900	25,400
1893-94	1,100	1,200	1,200	1,200	1,200	1,200	900	900	700	700	800	900	12,000
1894-95	1,100	1,200	1,800	2,500	3,200	5,300	1,700	1,300	800	700	800	900	21,300
1895-96	1,100	1,400	1,500	1,300	1,500	2,000	1,100	1,000	700	700	800	900	14,000
1896-97	1,100	1,200	1,330	1,490	4,420	5,780	3,540	1,530	910	700	800	900	23,700
1897-98	1,200	1,200	1,200	1,300	1,300	1,200	900	900	700	700	800	900	12,300
1898-99	1,000	1,100	1,100	1,100	1,100	1,100	800	800	700	700	700	800	11,000
1899-00	1,100	1,300	1,400	1,700	1,250	1,250	900	1,400	800	700	700	800	13,300
1900-01	1,100	2,600	1,200	2,100	5,600	2,200	1,100	1,200	800	700	800	900	20,300
1901-02	1,200	1,700	1,300	1,500	1,700	2,700	1,600	1,100	800	700	800	900	16,000
1902-03	1,100	1,200	1,300	1,600	1,400	3,300	6,900	1,900	900	700	800	900	22,000
1903-04	1,100	1,200	1,200	1,300	1,300	1,600	1,100	1,100	700	700	800	900	13,000
1904-05	1,100	1,300	1,300	1,400	10,200	31,200	5,500	4,000	1,400	1,100	900	900	60,300
1905-06	1,200	1,300	1,300	1,400	1,300	8,800	3,000	1,500	1,000	900	900	1,000	23,700
1906-07	1,500	1,600	2,200	18,400	15,700	47,900	17,500	3,200	2,100	1,400	1,200	1,300	114,000
1907-08	1,500	1,600	1,450	2,800	3,400	2,300	1,650	1,300	900	900	900	1,000	19,700
1908-09	1,200	1,300	1,300	2,800	5,000	2,300	2,300	1,350	950	900	900	1,000	21,300
1909-10	1,300	1,500	3,800	7,600	1,800	1,600	1,400	1,200	900	900	900	1,100	24,000
1910-11	1,300	1,400	1,400	2,700	3,300	6,600	1,800	1,300	1,000	900	900	1,100	23,700
1911-12	1,250	1,350	1,400	1,400	1,300	5,500	3,300	1,400	900	800	800	900	20,300
1912-13	1,000	1,100	1,100	1,500	4,800	1,900	1,050	950	700	700	700	800	16,300
1913-14	1,200	1,450	1,450	19,800	44,200	13,800	3,300	2,400	1,400	1,050	1,050	900	92,000
1914-15	1,500	1,600	2,000	3,000	15,200	7,200	5,300	8,000	2,500	1,450	1,150	1,100	50,000
1915-16	1,400	1,500	1,500	8,000	2,700	2,300	1,500	1,300	1,000	1,000	1,000	1,100	24,300
1916-17	1,450	1,500	2,100	2,500	3,600	2,000	1,500	1,250	900	700	800	1,000	19,300

1917-18	1,100	1,200	1,200	1,200	2,800	5,200	1,400	1,150	900	850	800	900	18,700
1918-19	1,550	1,800	2,100	1,350	2,150	2,100	1,800	1,150	800	700	700	800	17,000
1919-20	1,000	1,200	1,350	1,300	2,100	4,600	2,100	1,200	950	700	700	800	18,000
1920-21	1,100	1,250	1,300	2,300	2,200	3,100	1,500	2,300	1,200	850	800	800	18,700
1921-22	1,100	1,200	14,200	5,600	11,900	7,200	3,200	2,200	1,200	700	800	900	50,300
1922-23	1,300	1,600	2,900	1,900	2,000	1,800	1,600	1,200	900	800	900	1,000	17,700
1923-24	1,200	1,350	1,450	1,480	1,550	1,870	1,550	1,150	700	700	800	900	14,700
1924-25	1,120	1,220	1,250	1,300	1,400	1,650	2,660	1,200	880	820	700	800	15,000
1925-26	1,100	1,200	1,200	1,300	2,700	1,500	12 400	1,450	900	800	800	900	26,300
1926-27	1,200	1,700	1,470	1,410	7,430	2,900	2,100	1,360	930	700	800	1,000	23,000
1927-28	1,200	1,800	1,800	1,600	2,000	2,100	2,100	1,700	1,400	1,400	1,300	1,200	19,600
1928-29*	1,330	1,470	1,810	1,560	1,900	1,680	1,880	1,450	1,260	1,070	1,040	1,060	17,500
1929-30*	1,080	1,100	1,310	1,740	1,240	1,970	1,260	1,090	886	881	942	1,040	14,500
1930-31*	1,190	1,160	1,280	1,490	2,520	1,370	1,080	940	710	710	810	920	14,200
1931-32*	1,040	1,090	2,810	1,530	10,100	1,700	1,200	1,220	1,000	754	890	900	24,200
Mean													25,600

*Measured. All others estimated from rainfall-runoff relation.

TABLE 64

ESTIMATED COMBINED MONTHLY RUN-OFF, IN ACRE-FEET, OF PIRU CREEK AND CANALS AT PIRU

STATION No. 2-W

Season	October	November	December	January	February	March	April	May	June	July	August	September	Total
1892-93	600	700	9,100	22,400	26,300	30,100	9,400	9,100	4,500	2,200	200	400	115,000
1893-94	100	100	200	300	300	400	300	200	100	100	100	100	2,300
1894-95	200	200	2,200	4,300	6,800	13,900	2,500	1,300	500	200	0	200	32,300
1895-96	500	2,300	2,500	600	2,300	7,200	1,800	700	200	100	100	100	18,400
1896-97	300	100	200	1,000	12,000	16,900	9,700	2,400	500	300	200	100	43,700
1897-98	400	100	100	200	200	100	100	100	0	0	0	0	1,300
1898-99	300	300	500	800	600	1,200	500	200	100	0	100	0	4,600
1899-00	400	600	1,100	1,800	500	500	300	1,700	200	100	0	0	7,200
1900-01	0	3,700	100	2,400	11,400	2,600	600	700	300	100	0	0	21,900
1901-02	200	1,000	200	700	1,200	3,400	1,600	600	100	100	100	0	9,200
1902-03	100	100	200	1,300	600	7,000	16,900	3,000	500	100	100	100	30,000
1903-04	100	100	100	400	1,100	2,800	1,700	1,100	100	100	0	0	7,600
1904-05	200	200	300	700	33,700	107,000	16,700	11,100	2,500	1,400	700	500	175,000
1905-06	100	100	100	400	400	35,200	9,600	2,400	1,400	600	200	100	50,600
1906-07	300	300	1,300	28,900	24,300	78,800	27,700	3,600	2,000	900	500	400	169,000
1907-08	1,100	1,100	500	6,200	9,000	4,700	2,700	1,400	500	200	200	100	27,700
1908-09	500	500	700	33,100	79,800	23,800	27,800	7,200	2,500	1,100	500	500	178,000
1909-10	100	300	8,000	20,900	1,700	900	700	300	200	100	100	100	33,400
1910-11	500	500	500	35,500	48,500	136,000	17,200	5,300	1,800	1,000	700	500	248,000
1911-12	500	500	700	1,800	1,500	8,400	6,300	4,500	2,100	1,000	600	600	28,500
1912-13	900	1,300	1,000	4,200	11,400	14,900	6,300	2,000	2,200	800	1,500	600	47,100
1913-14	200	700	700	58,200	136,000	39,500	7,300	4,300	1,800	1,100	700	500	251,000
1914-15	300	200	900	2,600	22,200	9,400	6,700	11,000	2,600	900	400	400	57,600
1915-16	700	700	1,000	49,400	10,300	7,300	2,800	1,400	900	700	600	600	76,400
1916-17	1,200	800	4,100	5,500	11,100	4,400	2,400	1,300	500	300	200	100	31,900

1917-18	100	200	300	300	19,000	46,400	5,700	3,100	2,100	1,600	600	700	80,100
1918-19	1,300	1,600	2,500	600	2,600	2,500	2,400	900	300	100	100	100	15,000
1919-20	200	200	700	500	2,900	9,400	3,500	1,100	400	200	100	700	19,900
1920-21	100	400	500	2,400	2,300	3,800	1,300	3,000	1,000	200	200	200	15,400
1921-22	100	100	41,300	13,900	34,300	18,900	7,000	4,300	1,700	600	400	300	123,000
1922-23	500	1,000	6,300	2,300	2,500	1,900	2,200	800	500	200	100	100	18,400
1923-24	100	100	300	400	300	800	700	300	100	100	100	100	3,400
1924-25	100	100	100	100	300	500	1,800	400	100	100	100	100	3,800
1925-26	100	100	100	200	4,600	800	36,200	1,700	600	300	100	100	44,900
1926-27	100	1,700	600	500	26,100	6,700	4,400	1,300	600	300	200	100	42,600
1927-28*	314	381	1,070	1,050	3,360	2,390	1,100	409	263	228	105	82	10,800
1928-29*	167	630	1,320	994	1,530	1,770	2,520	542	229	92	63	47	9,910
1929-30*	84	122	161	1,650	472	4,260	1,330	1,020	143	85	63	51	9,440
1930-31*	52	87	146	967	7,940	816	1,140	793	333	83	173	178	12,700
1931-32*	88	583	5,740	2,150	34,800	5,450	2,060	1,110	536	208	147	125	53,000
Mean													53,200

*Measured. All others estimated from rainfall-runoff relation.

TABLE 65

ESTIMATED MONTHLY RUN-OFF, IN ACRE-FEET, OF HOPPER CREEK AT HIGHWAY BRIDGE

STATION No. 13-W

Season	October	November	December	January	February	March	April	May	June	July	August	September	Total
1892–93	60	40	900	2,200	2,600	2,900	900	870	450	0	0	0	10,920
1893–94	0	0	30	30	30	40	30	20	0	0	0	0	180
1894–95	20	10	160	310	500	1,000	190	100	40	0	0	0	2,330
1895–96	0	100	110	0	130	330	130	0	0	0	0	0	800
1896–97	0	0	100	100	1,520	2,140	1,250	300	110	0	0	0	5,520
1897–98	60	0	0	30	30	0	0	0	0	0	0	0	120
1898–99	0	0	100	110	170	110	0	0	0	0	0	0	490
1899–00	0	50	80	150	50	50	30	140	0	0	0	0	550
1900–01	0	260	0	160	720	180	0	0	0	0	0	0	1,320
1901–02	0	160	0	130	170	440	220	110	0	0	0	0	1,230
1902–03	0	0	0	200	100	1,100	2,600	500	100	0	0	0	4,600
1903–04	0	0	0	0	110	250	150	100	0	0	0	0	610
1904–05	0	0	0	60	1,800	5,770	900	600	130	0	0	0	9,260
1905–06	10	10	20	40	40	3,000	840	210	120	0	0	0	4,290
1906–07	0	0	120	2,100	1,700	5,600	2,000	250	230	0	0	0	12,000
1907–08	0	100	40	480	700	360	200	100	170	0	0	0	2,150
1908–09	50	50	120	2,200	5,300	1,600	1,840	500	140	0	0	0	11,800
1909–10	0	0	500	1,150	100	50	40	0	0	0	0	0	1,840
1910–11	0	20	100	1,400	1,800	5,000	700	60	0	0	0	0	9,080
1911–12	0	20	50	420	250	60	0	0	0	0	0	0	800
1912–13	0	0	0	0	120	1,020	220	70	40	0	0	0	1,470
1913–14	0	0	90	2,700	6,100	1,800	300	200	110	0	0	0	11,300
1914–15	60	100	100	300	2,550	1,100	800	1,250	300	0	0	0	6,560
1915–16	60	60	100	4,200	900	610	250	100	100	0	0	0	6,380
1916–17	150	140	500	650	1,300	550	300	150	0	0	0	0	3,740

1917-18	0	0	100	1,000	2,300	290	160	140	0	0	0	0	3,990
1918-19	70	80	150	50	140	140	60	50	0	0	0	0	740
1919-20	0	30	40	20	150	480	180	60	20	0	0	0	980
1920-21	0	50	50	260	250	410	150	310	110	0	0	0	1,590
1921-22	60	60	1,640	460	1,340	750	300	170	0	0	0	0	4,780
1922-23	40	70	450	160	170	130	150	60	0	0	0	0	1,230
1923-24	0	0	0	0	20	100	60	0	0	0	0	0	180
1924-25	20	20	30	40	30	70	260	50	30	0	0	0	550
1925-26	10	10	30	40	320	60	2,480	120	0	0	0	0	3,070
1926-27	20	210	80	80	3,220	830	540	160	70	0	0	0	5,210
1927-28	178	31	210	0	278	68	38	0	0	0	0	0	803
1928-29	0	73	275	104	139	186	211	0	0	0	0	0	988
1929-30	10	10	20	362	47	420	15	49	0	0	0	0	933
1930-31*	0	9	6	268	734	5	224	64	0	0	0	0	1,310
1931-32*	0	231	1,310	419	2,760	223	31	0	0	0	0	0	4,970
Mean													3,520

*Measured. All others estimated from rainfall-runoff relation.

TABLE 66

ESTIMATED MONTHLY RUN-OFF, IN ACRE-FEET, OF SESPE CREEK, NEAR FILLMORE, FOR PERIOD 1892-1932

STATION No. 3-W

Season	October	November	December	January	February	March	April	May	June	July	August	September	Total
1892-93 [a]	700	1,000	16,000	39,000	46,000	54,000	16,000	15,000	7,000	3,100	0	200	198,000
1893-94 [a]	200	400	800	1,400	1,200	1,600	600	200	100	0	0	0	6,500
1894-95 [a]	0	300	4,500	9,000	14,500	31,000	5,000	2,200	500	0	0	0	67,000
1895-96 [a]	700	4,000	4,500	1,000	4,200	13,200	2,700	700	0	0	0	0	31,000
1896-97 [a]	400	200	400	2,000	27,000	38,000	21,000	4,500	500	0	0	0	94,000
1897-98 [a]	800	0	0	300	300	0	0	0	0	0	0	0	1,400
1898-99 [a]	400	600	1,200	1,800	1,200	2,700	600	0	0	0	0	0	8,500
1899-00 [a]	600	1,100	2,100	3,800	900	900	100	3,000	0	0	0	0	12,500
1900-01 [a]	0	7,000	200	4,500	22,000	5,000	500	800	0	0	0	0	40,000
1901-02 [a]	200	1,800	500	1,500	2,500	6,500	2,500	500	0	0	0	0	16,000
1902-03 [a]	0	0	300	2,500	1,200	14,500	35,500	5,500	500	0	0	0	60,000
1903-04 [a]	0	100	200	600	2,100	5,500	3,000	1,500	0	0	0	0	13,000
1904-05 [a]	0	200	400	900	51,000	163,000	25,500	16,000	3,000	1,400	400	200	262,000
1905-06 [a]	0	300	200	600	700	77,500	21,000	4,600	2,500	600	0	0	108,000
1906-07 [a]	300	400	1,900	44,000	37,000	122,000	42,500	4,600	2,500	600	200	0	256,000
1907-08 [a]	2,200	2,300	1,000	14,000	20,000	10,000	5,000	2,500	500	0	0	0	57,500
1908-09 [a]	600	700	1,000	49,000	121,000	36,000	42,000	10,000	3,100	1,100	300	200	265,000
1909-10 [a]	0	500	17,000	46,000	3,500	1,900	1,100	0	0	0	0	0	70,000
1910-11 [a]	400	500	600	47,000	65,000	187,000	23,000	6,000	1,700	700	[a]600	[b]526	333,000
1911-12 [b]	658	726	1,140	1,040	555	26,300	14,500	2,900	484	36	0	0	48,300
1912-13 [b]	0	46	155	6,330	62,200	13,300	3,860	1,390	458	1	0	0	87,700
1913-14 [a]	200	900	900	79,500	185,000	53,500	9,000	5,000	1,600	800	400	200	337,000
1914-15 [a]	500	400	2,000	5,500	48,500	20,000	14,000	23,000	5,000	1,500	300	300	121,000
1915-16 [c]	1,000	1,100	1,700	95,000	19,000	13,000	5,000	2,100	1,100	800	600	600	141,000
1916-17 [c]	1,900	1,500	7,200	9,500	20,000	7,400	3,600	1,600	300	0	0	0	53,000

1917-18[c]	0	[a]200	[a]200	[a]300	[c]36,000	88,400	9,400	4,900	3,200	2,200	500	700	146,000
1918-19[a]	2,200	2,800	4,500	1,200	5,000	4,700	4,100	1,000	0	0	0	0	25,500
1919-20[c]	0	200	1,200	800	4,900	16,200	5,900	1,400	200	0	0	0	30,800
1920-21[c]	0	500	800	4,000	3,700	6,500	2,000	4,600	1,200	0	0	0	23,300
1921-22[c]	0	300	79,500	25,500	65,000	36,500	13,200	7,700	2,600	600	100	0	231,000
1922-23[c]	600	1,700	10,800	3,900	4,200	3,300	3,000	900	300	0	0	0	28,700
1923-24[c]	0	0	400	600	500	1,200	600	0	0	0	0	0	3,300
1924-25[c]	0	0	200	300	500	800	2,200	0	0	0	0	0	4,000
1925-26[c]	0	0	200	400	8,000	1,500	67,900	2,400	600	0	0	0	81,000
1926-27[a]	[c]0	[c]3,500	[a]1,200	1,000	60,000	16,000	9,500	2,100	700	0	0	0	94,000
1927-28[d]	99	676	1,740	1,300	6,570	5,110	1,290	17	0	0	0	0	16,800
1928-29[d]	0	370	1,460	1,450	3,720	4,380	4,510	815	14	0	0	0	16,700
1929-30[d]	0	0	0	2,150	859	9,290	2,190	1,040	18	0	0	0	15,500
1930-31[d]	0	68	39	1,080	8,000	907	2,010	1,880	341	0	0	0	14,300
1931-32[d]	0	829	12,300	5,500	51,900	6,040	2,300	1,160	125	0	0	0	80,200
Mean													87,500

[a] Flow estimated from rainfall-runoff curve, using index of seasonal wetness as developed for Sespe-Piru group.
[b] United States Geological Survey measurements at Southern Pacific Railroad Bridge, one-half mile southeast of Sespe.
[c] Estimated for Station 3-W, from measurements at Bradfield's Camp, in Santa Barbara National Forest, four and one-half miles above intake of Fillmore Canal, and six and one-half miles northwest of Sespe, Ventura County. Measured flow was multiplied by 1.19 (257÷216), and the product reduced to allow for estimated percolation loss and canal diversion.
[d] Measured flow at Division of Water Resources Gaging Station at highway bridge, one-half mile southeast of Sespe, Ventura County.

TABLE 67

ESTIMATED MONTHLY RUN-OFF, IN ACRE-FEET, OF SANTA PAULA CREEK FOR COMBINED FLOW OF MUD CREEK AND SANTA PAULA CREEK FOR PERIOD 1892-1932

STATION 4-W

Season	October	November	December	January	February	March	April	May	June	July	August	September	Total
1892-93 [a]	300	400	2,200	5,000	5,600	7,300	3,200	3,100	1,900	1,100	600	400	31,100
1893-94 [a]	0	0	100	100	100	200	100	100	100	100	100	0	800
1894-95 [a]	0	100	400	800	1,700	3,400	600	400	300	100	100	0	7,900
1895-96 [a]	100	500	600	100	500	1,500	400	200	100	100	0	0	4,100
1896-97 [a]	100	100	100	300	3,300	4,200	2,700	800	300	200	100	100	12,300
1897-98 [a]	0	0	0	100	100	100	0	0	0	0	0	0	300
1898-99 [a]	100	100	200	300	300	500	300	200	100	100	100	0	2,300
1899-00 [a]	200	200	300	700	200	200	100	600	200	100	100	100	3,000
1900-01 [a]	0	2,000	300	1,300	6,300	1,600	400	500	300	200	100	100	13,100
1901-02 [a]	100	400	200	400	600	1,400	900	400	200	100	100	0	4,800
1902-03 [a]	0	100	200	600	300	2,400	7,000	1,900	400	200	100	100	13,300
1903-04 [a]	100	100	100	100	300	1,000	700	500	100	100	0	0	3,100
1904-05 [a]	100	100	100	200	6,000	22,900	4,500	3,400	1,000	400	200	100	39,000
1905-06 [a]	0	100	100	300	300	10,200	5,500	1,300	900	300	200	100	19,300
1906-07 [a]	200	200	500	7,200	6,000	18,400	9,500	2,100	1,100	700	500	400	46,800
1907-08 [a]	400	400	300	1,900	2,600	2,100	1,500	900	400	300	200	200	11,200
1908-09 [a]	200	300	400	4,100	13,300	6,000	6,700	2,200	1,000	600	400	300	35,500
1909-10 [a]	100	200	2,100	5,500	900	500	400	300	200	200	100	100	10,800
1910-11 [a]	300	400	400	4,700	6,500	19,100	4,000	1,600	800	500	400	300	39,000
1911-12	200	[a]200	[a]300	[a]300	[a]200	[a]4,800	[b]2,750	[b]990	[b]506	[b]332	[b]215	[b]190	11,000
1912-13 [b]	150	150	156	824	5,900	2,700	1,040	571	379	254	160	119	12,400
1913-14 [a]	200	500	500	9,600	24,500	10,200	3,000	2,000	1,100	800	600	400	53,400
1914-15 [a]	200	200	400	800	6,200	3,700	2,900	3,100	1,500	700	400	300	20,400
1915-16 [a]	300	300	500	15,400	3,800	2,800	1,200	700	400	400	300	300	26,400
1916-17 [a]	500	400	1,600	2,200	4,000	1,700	1,000	600	300	100	100	100	12,600

1917–18[a]	100	100	100	100	6,400	14,800	2,200	1,300	900	700	300	400	27,400
1918–19[a]	200	300	500	200	500	600	600	300	100	100	0	0	3,400
1919–20[a]	100	100	300	200	1,100	3,400	1,400	500	200	100	100	100	7,600
1920–21[a]	100	200	200	1,000	900	1,500	600	1,200	500	100	100	100	6,500
1921–22[a]	100	100	13,200	5,000	11,200	6,400	2,800	1,700	800	300	200	100	41,900
1922–23[a]	200	400	2,400	900	1,000	800	900	400	300	200	200	100	7,800
1923–24[a]	100	100	200	200	200	400	300	100	100	100	0	0	1,800
1924–25[a]	0	100	100	100	100	200	700	200	100	100	100	0	1,800
1925–26[a]	0	100	100	100	1,800	400	11,600	800	400	200	100	100	15,700
1926–27[a]	100	900	400	300	10,300	4,500	3,100	1,300	600	200	200	100	22,000
1927–28[c]	131	165	294	322	681	1,040	335	223	129	85	59	34	3,500
1928–29[c]	54	192	333	367	639	675	812	341	180	86	48	52	3,680
1929–30[c]	49	51	79	492	226	1,280	379	289	153	96	61	48	3,150
1930–31	[c]49	[c]70	[c]95	[c]419	[c]1,280	[d]329	[d]435	[d]419	[d]272	[d]105	[d]71	[d]50	3,590
1931–32[d]	87	243	*2,000	*1,700	*12,100	2,080	901	643	400	225	154	150	20,700
Mean													15,100

[a] Flow estimated from rainfall run-off curve.
[b] Estimated for Station 4-W, from measurements by United States Geological Survey at east boundary of Ojai grant, in Santa Barbara National Forest, just below mouth of Sisar Creek, half a mile above Onlauf Canyon, six miles above junction with Santa Clara River, and five and one-half miles northwest of Santa Paula, Ventura County.
[c] Measured flow at Rafferty Bridge, near east boundary of Ex Mission San Buenaventura grant, three miles north of Santa Paula, Ventura County.
[d] Combined flow of Mud Creek and of Santa Paula Creek, measured at Station 3-W.

TABLE 68

ESTIMATED ANNUAL WATER CROP OF VENTURA RIVER WATERSHED ABOVE DIVERSION DAM OF VENTURA CITY AT MOUTH OF COYOTE CREEK, 1917-18 to 1931-32

Acre-feet

Season	Ventura River area	Coyote Creek	Matilija Creek	North Fork Matilija	San Antonio Creek	Total
1917-18	24,800	29,800	37,300	12,300	14,600	118,800
1918-19	1,100	1,500	7,500	2,700	1,700	14,500
1919-20	4,500	5,700	8,600	2,800	3,000	24,600
1920-21	4,200	4,300	6,800	2,300	3,700	21,300
1921-22	21,400	32,000	52,800	17,400	13,200	136,800
1922-23	5,900	8,300	14,500	4,800	3,800	37,300
1923-24	700	1,200	3,000	1,000	170	6,070
1924-25	350	500	1,600	530	1,100	4,080
1925-26	11,200	15,900	20,700	6,800	6,900	61,500
1926-27	12,400	17,100	27,900	8,600	13,200	79,200
1927-28	600	*808	*5,380	1,610	*1,700	10,100
1928-29	900	*1,430	*3,650	*1,270	*2,300	9,550
1929-30	*1,200	*1,720	*3,630	*1,160	*1,600	9,300
1930-31	*400	*563	*1,950	*698	*2,700	6,310
1931-32	*13,200	*15,100	*25,540	*7,380	*14,900	76,100
Average	----	----	----	----	----	41,000

*Measured. All others estimated from rainfall and relative area of watershed.

TABLE 1-A

ESTIMATES OF IRRIGABLE LAND

In Division of Water Resources Bulletin No. 43, South Coastal Basin Investigation "Value and Cost of Water for Irrigation in Coastal Plain of Southern California," by Frank Adams and Martin R. Huberty, authorities of the University of California on irrigation economics, is given an estimate of the additional irrigable land in Ventura County with the exception of Ventura River Basin. The authors do not consider any additional hill land "irrigable according to conservative standards" except in the vicinity of Moorpark.

The following table is condensed from Table 49 on page 112 of Bulletin 43:

		Estimated net acreage comparable with present irrigated areas		*Estimated gross additional acreage that would stand development under very favorable price conditions*	
Santa Clara River Valley in Ventura County		6,590		1,500	
Calleguas Creek Basin					
Pleasant Valley	3,185		2,500		
Las Posas Valley	1,940		9,000		
Simi Valley	2,570		1,700		
Santa Rosa Valley	510	8,205	4,000	17,200	
Coastal Plain		1,785			
		16,580		18,700	35,280

This is to be compared with Table 1, page 17, after subtracting the acreage in that table accredited to Ventura River Basin giving a modified total of 46,200 acres.

TABLE 69

ESTIMATED RUN-OFF TRIBUTARY TO PROPOSED RESERVOIRS, OR POINTS OF DIVERSION, OR AREAS OF USE, AND THE ESTIMATED RESIDUAL SUPPLY AVAILABLE TO THE VENTURA CITY DIVERSION WORKS AFTER POSSIBLE ULTIMATE UPSTREAM DEMANDS ARE SATISFIED

Acre-feet

Year, January to December, inclusive	Run-off to Matilija Reservoir	Run-off to Coyote Reservoir	Estimated diversion to Coyote from Santa Ana Creek	Total supply to Coyote Reservoir	Run-off San Antonio Creek above gaging station	Estimated rainfall penetration Ojai Basin	Run-off Ventura River area	Run-off North Fork at Matilija	Rainfall penetration to Ventura Basin	Estimated water supply at Ventura City diversion [a]
1918	39,800	13,100	5,800	18,900	15,200	3,790	25,000	13,200	4,600	[b]39,000
1919	5,300	570	330	900	1,300	250	970	1,900	620	6,100
1920	8,500	2,500	1,200	3,700	3,100	820	4,400	2,800	870	12,800
1921	25,900	6,400	3,000	9,400	7,900	1,000	11,200	8,600	1,130	52,500
1922	39,700	10,700	5,000	15,700	10,400	3,670	16,600	13,100	4,520	101,000
1923	8,700	2,200	1,300	3,500	2,200	1,120	3,400	2,900	1,500	22,000
1924	2,600	420	250	670	220	75	700	850	280	3,200
1925	1,600	230	130	360	1,100	190	350	550	500	3,800
1926	21,900	7,300	3,400	10,700	7,600	1,900	12,100	7,200	3,100	42,000
1927	27,800	7,000	3,300	10,300	13,000	3,500	11,400	8,600	4,500	66,200
1928	4,500	380	220	600	1,900	460	620	1,300	590	5,300
1929	3,400	570	250	820	1,500	290	840	1,200	710	4,900
1930	3,700	750	360	1,100	1,600	330	1,200	1,200	530	8,700
1931	4,800	2,100	900	3,000	7,100	700	4,300	1,500	880	6,800
1932[c]	22,500	4,600	2,200	8,800	10,500	3,850	9,300	6,500	5,100	51,000

[a] Includes return water from Coyote and Upper Ventura irrigation and ground water outflow from Ojai Basin.
[b] April to December only.
[c] January to September, inclusive.
NOTE: All quantities in acre-feet.

TABLE 70

CROP CENSUS, 1932

SANTA CLARA RIVER VALLEY, CALLEGUAS CREEK VALLEY AND COASTAL PLAIN

Area in Acres

Basin	Valley					Hills			Total		
	Irrigable			Not irrigable	Total	Irrigable			Irrigable	Irrigated*	Remaining irrigable
	Irrigated*	Not irrigated	Total			Irrigated*	Not irrigated	Total			
Eastern	2,763	11,619	14,382	6,910	21,292	115	308	423	14,805	**2,878	11,927
Piru	3,608	2,500	6,108	3,360	9,468	125	389	514	6,622	3,733	2,889
Fillmore	8,979	4,454	13,433	3,446	16,879	142	716	858	14,291	9,121	5,170
Santa Paula	10,963	2,610	13,573	1,794	15,367	561	970	1,531	15,104	11,524	3,580
Montalvo, North	6,817	720	7,537	76	7,613	88	317	405	7,942	6,905	1,037
Montalvo, South	7,962	981	8,943	1,727	10,670	41	71	112	9,055	8,003	1,052
Ventura	1,184	167	1,351		1,351	116	143	259	1,610	1,300	310
Beach	298	302	600	5,472	6,072				600	298	302
Oxnard, North	1,836	393	2,229	63	2,292				2,229	1,836	393
Oxnard, South	26,659	3,426	30,085	1,549	31,634				30,085	26,659	3,426
West Las Posas	4,135	1,302	5,437	296	5,733	108	899	1,007	6,444	4,243	2,201
Las Posas (Moorpark)	6,306	3,410	9,716	1,256	10,972	687	6,016	6,703	16,419	6,993	9,426
Simi	6,998	3,526	10,524	689	11,213	254	1,083	1,337	11,861	7,252	4,609
Conejo (Santa Rosa)	2,551	4,156	6,707	175	6,882	1,015	3,224	4,239	10,946	3,566	7,380
Pleasant Valley above "pressure line"	10,395	2,163	12,558	385	12,943	197	637	834	13,392	10,592	2,800
Pleasant Valley below "pressure line"	4,753	2,572	7,325	199	7,524				7,325	4,753	2,572
Totals	106,207	44,301	150,508	27,397	177,905	3,449	14,773	18,222	168,730	109,656	59,074

*Irrigated land and subdivision: Total subdivision, 3,708 acres; total irrigated land, 105,948 acres.

**2,463 acres in Los Angeles County.

NOTE: The figures shown in this table for irrigable valley lands not irrigated are 75% of the unirrigated irrigable valley lands shown on the crop map in rear pocket, except for Oxnard, South, which are 50%, and the figures shown for the irrigable hills are 25% of the irrigable or habitable hill lands shown on the same map.

TABLE 71

CROP CENSUS, 1932

VENTURA RIVER BASIN

Area in Acres

Basin	Valley					Hills			Total		
	Irrigable			Not irrigable	Total	Irrigable		Total			
	Irrigated*	Not irrigated	Total			Irrigated*	Not irrigated		Irrigable	Irrigated*	Remaining irrigable
Coyote Creek	167	1,983	2,150	181	2,331	----	327	327	2,477	167	2,310
San Antonio Creek—											
Ojai Valley	1,523	1,850	3,373	241	3,614	17	154	171	3,544	1,540	2,004
Libby-Pirie	251	463	714	30	744	39	232	271	985	290	695
Upper Ojai	94	1,182	1,276	66	1,342	16	300	316	1,592	110	1,482
Creek Road	67	292	359	64	423	----	103	103	462	67	395
Totals San Antonio	1,935	3,787	5,722	401	6,123	72	789	861	6,583	2,007	4,576
Fresno Canyon	----	----	----	----	----	----	62	62	62	----	62
Ventura River	1,005	2,836	3,841	1,200	5,041	37	552	589	4,430	1,042	3,388
Totals above Casitas Road	3,107	8,606	11,713	1,782	13,495	109	1,730	1,839	13,552	3,216	10,336
Canada Larga	----	526	526	45	571	----	----	----	526	----	526
Avenue	1,319	779	2,098	642	2,740	----	115	115	2,213	1,319	894
Grand totals	4,426	9,911	14,337	2,469	16,806	109	1,845	1,954	16,291	[a]4,535	11,756

*Irrigated land and subdivision. Total subdivision, 1,015 acres. Total irrigated land, 3,520 acres.

[a] Additional 128 acres irrigated in Rincon Creek area.

NOTE: The figures shown in this table for irrigable valley lands not irrigated are 75% of the unirrigated irrigable valley lands shown on the crop map in rear pocket, and the figures shown for the irrigable hills not irrigated are 25% of the habitable hill land shown on the same map.

TABLE 72

CAMARILLO CANAL

From Spreading Grounds to Camarillo Reservoir; Capacity, 200 Second-feet

ESTIMATE OF COST

Flow tunnel. 2,300′, 7′ diameter circular section:				
Excavation	5,400 cu. yds. at	$5 00	$27,000	
Lining	2,150 cu. yds. at	20 00	43,000	
				$70,000
Pressure tunnel. 800′, 7′ diameter circular section:				
Excavation	1,900 cu. yds. at	$5 00	$9,500	
Lining	800 cu. yds. at	25 00	20,000	
				30,000
Flumes (5′ x 12′ water section)	1,100 lin. ft. at	$20 00		22,000
Pressure pipe (7′ diameter)	2,000 feet at	17 50		35,000
Railroad crossing (7′ pipe)	100 feet at	20 00	$2,000	
	Temporary work, etc.		3,000	
				5,000
Pressure pipe (7½′ diameter)	2,800 feet at	$20 00		56,000
Flow pipe (7½′ diameter)	4,000 feet at	17 50		70,000
Highway crossings (5′ x 12′)	400 feet at	30 00		12,000
Canal pipe line excavation:				
Earth excavation	220,000 cu. yds. at	$0 20	$44,000	
Hardpan	100,000 cu. yds. at	0 50	50,000	
Backfill	50,000 cu. yds. at	0 12	6,000	
				100,000
Canal lining	66,000 lin. ft. at	$4 00		264,000
Emergency spillways				16,000
Right of way:				
Orchard	25 acres at	$3,000	$75,000	
Cultivated	25 acres at	1,000	25,000	
Uncultivated (side hill)	75 acres at	200	15,000	
Farm bridges	25 acres at	200	500	
				120,000
				$800,000
Pumping plant, 200 c. f. s., 87½ ft.	17,500 sec. ft. at	$10 00		175,000
BASE COST				$975,000
Engineering, administration and contingencies—25%				245,000
Interest during construction—rate 6%				80,000
TOTAL COST				$1,300,000

TABLE 73

CONDUIT FROM SATICOY SPREADING GROUNDS TO PLEASANT VALLEY

Capacity, 75 Second-feet

ESTIMATE OF COST

Station 25 to 500, 75 second-foot capacity:				
Excavation—				
Earth	90,000 cu. yds. at	$0 20	$18,000	
Hardpan	20,000 cu. yds. at	0 50	10,000	
Backfill	16,600 cu. yds. at	0 12	2,000	
				$30,000
Canal lining	38,000 lin. ft. at	$3 00		114,000
Tunnel	24,000 feet at	25 00		60,000
Pressure pipe, 60″	3,000 feet at	10 00		30,000
Flow (60″) pipe	3,000 feet at	8 00		24,000
Flume	11,000 feet at	10 00		11,000
Station 500 to 702:				
Excavation—				
Earth	20,000 cu. yds. at	$0 20	$8,000	
Hardpan	5,000 cu. yds. at	0 50	2,500	
Backfill	400 cu. yds. at	0 12	500	
				11,000
Canal lining	18,500 lin. ft. at	$2 00		37,000
Railroad crossing	100 feet			3,000
Flume—Calleguas Creek	150 feet			2,000
Pipe (42″)	1,600 feet at	$5 00		8,000
Station 702 to 742	3,000 feet at	$3 00		9,000
Right of way:				
Orchard	20 acres at	$3,000		
Cultivated	18 acres at	1,000		
Uncultivated	50 acres at	200		
Farm bridges	20 acres at	100		
				90,000
Spillways				11,000
BASE COST				$440,000
Engineering, administration and contingencies—25%				110,000
Interest during construction—rate 6%				33,000
TOTAL COST				$583,000

TABLE 74

SANTA PAULA BASIN PUMPING PLANTS AND CONDUIT FROM ABOVE WILLARD BRIDGE TO SATICOY SPREADING WORKS

ESTIMATE OF COST

Headworks at Turner Ditch Intake				$10,000
Lined canal (bottom width 3′, depth 2′, 1¼ to 1 slopes)	8,000 lin. ft.	at	$2 50	20,000
36″ pipe line	8,000 lin. ft.	at	5 00	40,000
42″ pipe line	8,000 lin. ft.	at	6 00	48,000
48″ pipe line	8,000 lin. ft.	at	7 00	56,000
18″ pipe feeders	10,000 lin. ft.	at	1 50	15,000
30 wells—2½ second-feet equipment for 60-foot lift				75,000
Right-of-way, roadways, etc.				16,000
BASE COST				$280,000
Engineering, administration and contingencies—25%				70,000
Interest during construction—rate 6%				21,000
TOTAL COST				$371,000

TABLE 75

PIRU SPREADING WORKS

Plan, 4,900-foot Tunnel and Pipe Line

ESTIMATE OF COST

Dam and diversion works—Piru Creek:					
Excavation—					
Stripping dam foundation	5,600 cu. yds.	at	$0 50	$2,800	
Cut-off wall	320 cu. yds.	at	4 00	1,280	
Rock excavation	625 cu. yds.	at	2 00	1,250	
Levee embankment	3,000 cu. yds.	at	00	0	
Concrete and masonry—					
Dam	2,025 cu. yds.	at	$8 00	$16,200	
Cut-off wall	320 cu. yds.	at	10 00	3,200	
Stream bed paving	400 cu. yds.	at	6 00	2,400	
Bank protection	80 cu. yds.	at	6 00	480	
Reinforced concrete—					
Weir chamber and inlet tower	193 cu. yds.				
Head and wing walls for levee	107 cu. yds.				
	300 cu. yds.	at	$20 00	6,000	
Gates—					
2—7′ x 16′ radial gates	2	at	$1,500	3,000	
2—5′ x 18′ radial gates	2	at	1,400	2,800	
					$39,410
Tunnel (6.5′ net diameter, 4,900′ long)—					
Excavation	8,700 cu. yds.	at	$5 00	$43,500	
Concrete lining	3,400 cu. yds.	at	20 00	68,000	
					111,500
Pipe line—					
Excavation below South Tunnel portal	1,000 cu. yds.	at	$0 30	$300	
2—6′ reducers, 6.5′ to 5′, installed				100	
2,400 lin. ft. pipe at $10.00				24,000	
Vent pipe, 40′-30′, Calco pipe				100	
Stilling well and weir control complete				2,100	
					26,600
Spreading works—					
Levees	362,600 cu. yds.	at	$0 15	$54,390	
Strip checking grounds	123 acres	at	30 00	3,690	
Paving and flexible mattress	220,400 sq. ft.	at	0 15	33,060	
Sluice pipes—basin outlets	2 complete	at	750 00	1,500	
Outlet from basins—					
3—36″ pipe outlets from upper basin	3	at	$450 00	1,350	
10—outlets to spreading grounds	10	at	350 00	3,500	
Spillway from basin	2	at	500 00	1,000	
					98,490
Right-of-way					35,000
BASE COST					$311,000
Engineering, administration and contingencies—25%					78,000
Interest during construction—rate 6%					12,000
TOTAL COST					$401,000

TABLE 76

PIRU CREEK SPREADING WORKS

Alternate Plan

ESTIMATE OF COST

Dam and diversion works—Piru Creek:				
Excavation—				
Stripping foundation	3,600 cu. yds. at	$0 50	$1,800	
Cut-off wall	500 cu. yds. at	4 00	2,000	
Stream bed and banks	400 cu. yds. at	0 20	80	
Stream bed and banks	3,500 cu. yds. at	0 50	1,750	
Levee on right bank	5,000 cu. yds. at	0 20	1,000	
				$6,630
Concrete—				
Mass concrete in dam	4,850 cu. yds. at	$8 00	$38,800	
Cut-off wall	500 cu. yds. at	6 00	3,000	
Paving stream bed and banks	1,300 cu. yds. at	8 00	10,400	
Radial gates for sluiceway	2 at	2,000	4,000	
				56,200
Diversion canal and inlet works—				
Excavation settling basin	260 cu. yds. at	$0 50	$130	
Cut and cover section	1,400 cu. yds. at	0 50	700	
Open cut work	71,600 cu. yds. at	0 20	14,320	
Syphon trench	2,800 cu. yds. at	1 00	2,800	
				17,950
Concrete—				
Lining of inlet basin and weir wall	32 cu. yds. at	$15 00	$480	
Cut and cover section	142 cu. yds. at	15 00	2,130	
Canal lining	3,750 lin. ft. at	2 65	9,940	
Canal lining	2,800 lin. ft. at	2 40	6,720	
Canal lining	700 lin. ft. at	5 00	3,500	
Inlet box to syphon	32 cu. yds. at	15 00	480	
Concrete pipe for syphon	570 feet at	15 00	8,550	
				31,800
Sluice pipes	300 lin. ft. at	$5 00	$1,500	
Slide gates	2 at	250 00	500	
Slide gates	2 at	1,000 00	2,000	
				4,000
Tunnel—				
Excavation	4,300 cu. yds. at	$5 00	$21,500	
Concrete lining	1,620 cu. yds. at	20 00	32,400	
Concrete head walls	50 cu. yds. at	20 00	1,000	
				54,900
Pipe line to spreading grounds—				
2,300 feet—48″ pipe installed	at	$6 00	$13,800	
Stilling well and weir			2,100	
				15,900
Spreading works—				
Dikes	362,600 cu. yds. at	$0 15	$54,390	
Strip checking grounds	123 acres at	30 00	3,690	
Rock mattress dike protection	220,400 cu. yds. at	0 15	33,060	
Sluice pipes	2 complete at	750 00	1,500	
Outlets—upper basin	3 complete at	450 00	1,350	
Outlets—basin to ground	10 complete at	350 00	3,500	
Spillway basins	2 complete at	500 00	1,000	
				98,490
Right-of-way				35,000
BASE COST				$321,000
Administration, engineering and contingencies—25%				80,000
Interest during construction—rate 6%				12,000
TOTAL COST				$413,000

TABLE 77

MONTALVO SPREADING WORKS

Diversion dam:					
Excavation	4,200 cu. yds.	at	$0 50	$2,100	
Sheet piling steel	364,000 lbs.	at	0 05	18,200	
Reinforced concrete piling	1,440	at	2 00	2,880	
Concrete—					
Floor slab and footing	690 cu. yds.	at	8 00	5,520	
Piers and walls	730 cu. yds.	at	10 00	7,300	
Deck and beams	12 cu. yds.	at	12 50	150	
Reinforcing steel	134,000 lbs.	at	0 06	8,040	
Gates—					
4 roller gates		at	2,500	10,000	
1—20′ Taintor gate		at	1,500	1,500	
1—16′ Taintor gate, with automatic control				1,500	
Footbridge				1,200	
Rockfill and cleaning				1,610	
BASE COST					$60,000
Main canal: 400 second-foot capacity, 2,400 lin. ft. Bottom width, 15 feet; water depth, 5 feet; side slopes, $1\frac{1}{4}$ to 1; grade .00025.					
Excavation	16,000 cu. yds.	at	$0 15	$2,400	
Concrete lining	72,000 sq. ft.	at	0 15	10,800	
Turnout structure, concrete	100 cu. yds.	at	12 50	1,250	
Turnout structure, reinforcing steel	9,100 lbs.	at	0 06	550	
3—5′ x 10′ radial gates		at	500 00	1,500	
					16,500
Levee and paving, above desilting basin:					
Levee	15,000 cu. yds.	at	$0 20	$3,000	
Flexible mattress or paving	50,000 sq. ft.	at	0 15	7,500	
					10,500
Desilting basins:					
Levees	180,000 cu. yds.	at	$0 20	$36,000	
Flexible mattress and paving	160,000 sq. ft.	at	0 15	24,000	
Feed canal, outlets to basin				2,000	
Excavation for inside channel, included in levee fills				0	
Lining outlets and sluicing canal	45,000 sq. ft.	at	0 15	6,750	
Spillway lining	5,000 sq. ft.	at	0 15	750	
Sluicing gates	2	at	1,000	2,000	
Pipe for sluicing outlets	300 ft.	at	5 00	1,500	
					73,000
By-pass canal (lined, bottom 6′, depth 3′, side slope $1\frac{1}{4}$ to 1). 2,500 feet		at	$3 20		8,000
Distributing canals:					
Above Del Norte Avenue—					
Lined canal	5,000 ft.	at	$3 00	$15,000	
Unlined canal	2,000 ft.	at	0 25	500	
Unlined canal	2,500 ft.	at	0 20	500	
Turnouts, gates and wasteways				4,000	
					20,000
Spreading dikes and road levees, above Del Norte Avenue—					
Road with levees	15,000 ft.	at	$0 30	$4,500	
Minor levees	20,000 ft.	at	0 15	3,000	
Additional for roads along canal				500	
					8,000
TOTAL above Del Norte Avenue					$196,000
Spreading works below Del Norte Avenue:					
Distributing canals—					
Pipe under Del Norte Avenue	200 ft.	at	$5 00	$1,000	
Lined canal, section	2,500 ft.	at	2 40	6,000	
Lined canal, section	1,200 ft.	at	2 00	2,400	
Unlined canal	300 ft.	at	0 30	900	
Turnouts and wasteways				2,200	
					$12,500
Spreading dykes and road levees—					
Road width levees	15,000 ft.	at	$0 30	$4,500	
Minor levees				3,000	
					7,500
TOTAL below Del Norte Ave					$20,000
Total above and below Del Norte Avenue					$216,000
Right-of-way					54,000
BASE COST					$270,000
Engineering, administration and contingencies—25%					68,000
Interest during construction—rate 6%					10,000
TOTAL COST					$348,000

TABLE 78

VENTURA RIVER SPREADING WORKS

ESTIMATE OF COST

Diversion dam:				
Excavation	1,000 cu. yds. at	$0 50	$500	
Mass concrete	600 cu. yds. at	8 00	4,800	
Formed concrete	125 cu. yds. at	12 00	1,500	
Paving concrete	100 cu. yds. at	10 00	1,000	
Reinforcing steel	10,000 lbs. at	0 06	600	
Flexible mattress	6,000 sq. ft. at	0 20	1,200	
Radial gates	1 at $500, 2 at $300		1,100	
Steel rails, secondhand	65 tons at	20 00	1,300	
				$12,000
Diversion channel, 500′ long:				
Excavation	5,000 cu. yds. at	$0 20	$1,000	
Lining	8,000 sq. ft. at	0 15	1,200	
Covered section	190 cu. yds. at	20 00	3,800	
				$6,000
Cozy Dell Creek, diversion levee (1,000′—5′ ht.):				
	5,000 cu. yds. at	$0 20	$1,000	
	5,000 cu. yds. from channel		0	
				$1,000
Levees above and below diversion dam:				
	11,000 cu. yds. at	$0 20	$2,200	$2,200
Flexible mattress	5,000 sq. ft. at	0 20	1,000	1,000
Road levees (20,000 lin. ft. at 1.6 cu. yd. per ft.):				
	32,000 cu. yds. at	0 15	$4,800	$4,800
Contour spreading levees (120,000 lin. ft. at 1.0 cu yd. per ft.):				
	120,000 cu. yds. at	$0 10	$12,000	$12,000
Cross-channel levees:				
	85,000 cu. yds. at	$0 20	$17,000	$17,000
Cross-channel controls:				
	20–20′ opening at	$600	$12,000	
	32–20′ opening at	750	24,000	
				$36,000
Laterals and outlets				4,000
Right of-way				14,000
BASE COST				$110,000
Engineering, administration and contingencies—25%				28,000
Interest during construction—rate 6%				4,000
TOTAL COST				$142,000

TABLE 79

PIPE LINE, MATILIJA RESERVOIR TO OJAI VALLEY

Capacity, 25 Second-feet

Estimate is only approximate as no detailed survey was made. The estimate of length and of excavation is based on field reconnaissance and U. S. G. S. topographic maps.

Station 0—180 24″ pipe required
Station 180—330 30″ pipe required
Excavation for 24″ pipe—.75 cu. yds. per foot
Excavation for 30″ pipe—1.00 cu. yds. per foot

Excavation:				
	4,000 lin. ft. at	$2 25	$9,000	
	2,800 lin. ft. at	0 75	2,100	
	4,000 lin. ft. at	2 00	8,000	
	7,200 lin. ft. at	0 40	2,900	
	15,000 lin. ft. at	1 00	15,000	
				$37,000
Backfill	30,000 cu. yds. at	$0 10		3,000
Ventura River crossing				3,000
Spun concrete pipe laid in trench:				
24″ diameter—				
	8,700 ft. high head at	$4 05	$35,000	
	9,300 ft. low head at	3 25	30,000	
30″ diameter	15,000 ft. low head at	3 75	56,000	
				121,000
Right-of-way and stripping				3,000
BASE COST				$167,000
Engineering, administration and contingencies—25%				41,750
Interest during construction—6% rate				6,250
TOTAL COST				$215,000

TABLE 80

COST OF LOS ALAMOS RESERVOIR

With 135-foot Slab and Buttress Dam

Crest of dam, elevation 2,400 feet, U. S. G. S. datum — Capacity of reservoir, 10,400 acre-feet
Crest of spillway, elevation 2,380 feet — Capacity of spillway, 61,000 second-feet

Dam and spillway:					
Excavation—					
Gravel—wet	27,400 cu. yds.	at	$1 50	$41,100	
Loose shale	5,450 cu. yds.	at	1 00	5,500	
Footing and cut-off trenches	6,160 cu. yds.	at	5 00	30,800	
					$77,400
Concrete—					
Buttresses	32,800 cu. yds	at.	$18 00	$590,000	
Buttress footings	4,900 cu. yds.	at	15 00	73,500	
Struts and walks	600 cu. yds.	at	25 50	15,300	
Slabs	8,040 cu. yds.	at	18 50	149,000	
Cut-off walls	1,260 cu. yds.	at	15 00	18,900	
Spillway walls	300 cu. yds.	at	23 50	7,100	
Bucket and apron	2,480 cu. yds.	at	16 50	40,900	
Parapet	80 cu. yds.	at	18 50	1,500	
					896,200
Drilling and grouting	510 ft. of dam	at	25 00	$12,800	
					12,800
Outlets—					
Concrete trash racks	10 cu. yds.	at	$18 50	$200	
Trash racks	1,500 lbs.	at	0 10	200	
Steel pipe	160 ft.	at	13 50	2,200	
Needle valves—36-inch	2	at	7,600 00	15,200	
Slide gates—36-inch	2	at	4,800 00	9,600	
					27,400
Reservoir[1]:					
Lands				$5,000	
Transmission line	1 26 mi.	at	$25,000 00	31,500	
26″ gas line	89 mi.	at	50,000 00	44,500	
22″ gas line	89 mi.	at	50,000 00	44,500	
8″ oil line	.60 mi.	at	40,000 00	24,000	
Telephone line	94 mi.	at	2,000 00	1,900	
Clearing—brush	120 acres	at	20 00	2,400	
trees	10 acres	at	50 00	500	
					154,300
Sub-total					$1,168,100
Administration, engineering and contingencies, 25%					292,000
Interest during construction—6% rate—1 year period					88,900
TOTAL COST					$1,549,000

[1] No charge for relocating the State highway is included in estimate.

TABLE 81

COST OF LIEBRE CREEK DIVERSION TO LOS ALAMOS RESERVOIR

Headworks:					
Liebre Creek—					
Dam—Excavation	32 cu. yds.	at	$3 00	$100	
Concrete	32 cu. yds.	at	25 00	800	
Headgate	1	at	250 00	250	
West Fork—					
Dam—Excavation	143 cu. yds.	at	$3 00	430	
Concrete	124 cu. yds.	at	25 00	3,100	
Headgate	1	at	250 00	250	
					$4,930
Canal:					
Liebre Creek—Excavation	15,200 cu. yds.	at	$0 50	$7,600	
Concrete lining	540 cu. yds.	at	20 00	10,800	
West Fork— Excavation	5,430 cu. yds.	at	0 50	2,720	
Concrete lining	310 cu. yds.	at	20 00	6,200	
Combined— Excavation—Ditch	380 cu. yds.	at	0 50	190	
Trench	400 cu. yds.	at	0 50	200	
Backfill	300 cu. yds.	at	0 25	80	
Concrete lining	20 cu. yds.	at	20 00	400	
60-inch pipe	70 ft.	at	10 00	700	
60-inch gate	1	at	150 00	150	
					29,040
Flumes:					
Liebre Creek—Metal flume	475 lin. ft.	at	$2 35	$1,120	
Sub-structure	9,570 F. B. M.	at	110 00 per M	1,050	
West Fork— Metal flume	100 lin. ft.	at	2 00	200	
Sub-structure	1,020 F. B. M.	at	110 00 per M	110	
Combined— Metal flume	400 lin. ft.	at	2 60	1,040	
Sub-structure	20,670 F. B. M.	at	110 00 per M	2,270	
Inlet structure	1	at	200 00	200	
					5,990
Sand boxes and spillways	2	at	200 00	$400	
					400
Sub-total					$40,360
Administration, engineering and contingencies, 25%					10,090
Interest during construction—6% rate—½ year					1,510
TOTAL COST					$51,960

TABLE 82

COST OF SPRING CREEK RESERVOIR ON PIRU CREEK

With 185-foot Variable Radius Concrete Arch Dam

Crest of dam, elevation 2,180 feet, U. S. G. S. datum — Capacity of reservoir, 20,200 acre-feet
Crest of spillway, elevation 2,160 feet — Capacity of spillway, 73,000 second-feet

Dam (including spillway):					
Excavation—					
Gravel and talus	63,900 cu. yds.	at	$1 50	$95,900	
Rock—wet	8,200 cu. yds.	at	3 50	28,700	
Dry	20,500 cu. yds.	at	2 50	51,300	
					$175,900
Concrete—					
Mass—arch	136,100 cu. yds.	at	$8 50	$1,156,900	
Outlet tower	1,100 cu. yds.	at	8 50	9,350	
Reinforced—parapets	140 cu. yds.	at	17 25	2,420	
Outlet tower	515 cu. yds.	at	17 25	8,900	
					1,177,570
Grouting and seals	550 ft. of dam	at	$30 00	$16,500	
					16,500
Outlets—					
Trash racks	1,500 lbs.	at	$0 10	$150	
Steel pipe—36-inch	200 ft.	at	13 50	2,700	
Roller gates—4′ x 4′	2	at	5,300 00	10,600	
Needle valves—36-inch	2	at	10,100 00	20,200	
					33,650
Backfill	16,700 cu. yds.	at	$0 25	$4,180	
					4,180
Reservoir[1]:					
Land			No cost		
Transmission line	0.75 mi.	at	$25,000 00	$18,800	
Clearing—brush	148 acres	at	20 00	2,960	
Trees	30 acres	at	50 00	1,500	
					23,260
Sub-total					$1,431,060
Administration, engineering and contingencies, 25%					357,760
Interest during construction—6% rate—1½-year period					165,820
TOTAL COST					$1,954,640

[1] Does not include cost of relocation of State highway.

TABLE 83

COST OF SPRING CREEK RESERVOIR ON PIRU CREEK

With 283-foot Variable Radius Concrete Arch Dam

Crest of dam, elevation 2,278 feet, U. S. G. S. datum — Capacity of reservoir, 61,500 acre-feet
Crest of spillway, elevation 2,261 feet — Capacity of spillway, 73,000 second-feet

Dam:				
Excavation—				
Gravel and talus	80,200 cu. yds. at	$1 50	$120,300	
Rock—wet	10,500 cu. yds. at	3 50	36,800	
Dry	50,500 cu. yds. at	2 50	126,300	
				$283,400
Concrete—				
Mass—arch section	306,900 cu. yds. at	$8 50	$2,608,700	
Gravity section	21,400 cu. yds. at	8 50	181,900	
Outlet tower	1,600 cu. yds. at	8 50	13,600	
Reinforced—parapets	180 cu. yds. at	17 25	3,110	
Outlet tower	620 cu. yds. at	17 25	10,700	
				2,818,010
Grouting and seals	700 ft. of dam at	$30 00	$21,000	
				21,000
Outlets—				
Trash racks	1,500 lbs. at	$0 10	$150	
Steel pipe—36-inch	250 ft. at	13 50	3,380	
Roller gates—4′ x 4′	2 at	6,000 00	12,000	
Needle valves—36-inch	2 at	14,300 00	28,600	
				44,130
Backfill	18,900 cu. yds. at	$0 25	$4,730	
				4,730
Spillway (shaft and tunnel type):				
Excavation—				
Inlet	35,180 cu. yds. at	$2 50	$88,000	
Shaft	10,740 cu. yds. at	8 00	85,900	
Tunnel	12,960 cu. yds. at	6 50	84,200	
Weir	16,880 cu. yds. at	2 50	42,200	
				300,300
Concrete—				
Mass—weir	14,280 cu. yds. at	$9 50	$135,700	
Reinforced—paving	710 cu. yds. at	14 50	10,300	
Shaft and tunnel lining	3,750 cu. yds. at	20 25	75,900	
				221,900
Reservoir*:				
Land		No cost		
Transmission line	2 8 mi. at	$25,000 00	$70,000	
Clearing—brush	260 acres at	20 00	5,200	
Trees	50 acres at	50 00	2,500	
				77,700
Sub-total				$3,771,170
Administration, engineering and contingencies, 25%				942,790
Interest during construction—6% rate—2½-year period				750,930
TOTAL COST				$5,464,890

* Does not include cost of relocation of State highway.

TABLE 84

COST OF SPRING CREEK RESERVOIR ON PIRU CREEK

With 185-foot Gravity Concrete Dam

Crest of dam, elevation 2,180 feet, U. S. G. S. datum
Crest of spillway, elevation 2,160 feet

Capacity of reservoir, 20,200 acre-feet
Capacity of spillway, 73,000 second-feet

Dam (including spillway):					
Excavation—					
Gravel—wet	65,500 cu. yds. at		$1 50	$98,300	
Common—dry	29,800 cu. yds. at		0 40	11,900	
Rock—wet	13,200 cu. yds. at		3 50	46,200	
Dry	27,700 cu. yds. at		2 50	69,300	
Cut-off trench	1,680 cu. yds. at		6 00	10,100	
					$235,800
Concrete—					
Mass	219,300 cu. yds. at		$6 00	$1,315,800	
Reinforced—parapets	250 cu. yds. at		17 25	4,310	
Gate towers and house	90 cu. yds. at		17 25	1,550	
					1,321,660
Grouting, drainage and seals	490 ft. of dam at		$90 00	$44,100	
					44,100
Outlets—					
Steel pipe—36-inch	140 ft.	at	$13 50	$1,890	
Trash racks	1,500 lbs.	at	0 10	150	
Roller gates—4′ x 4′	2	at	5,300 00	10,600	
Needle valves—36-inch	2	at	10,100 00	20,200	
					32,840
Backfill	43,200 cu. yds. at		$0 25	$10,800	
					10,800
Reservoir[1]:					
Land			No cost		
Transmission line	0 75 mi.	at	$25,000 00	$18,800	
Clearing—brush	148 acres	at	20 00	2,960	
Trees	30 acres	at	50 00	1,500	
					23,260
Sub-total					$1,668,460
Administration, engineering and contingencies, 25%					417,120
Interest during construction—6% rate—1-year period					127,010
TOTAL COST					$2,212,590

[1] Does not include cost of relocation of State highway.

TABLE 85

COST OF SPRING CREEK RESERVOIR ON PIRU CREEK

With 280-foot Gravity Concrete Dam

Crest of dam, elevation 2,275 feet, U. S. G. S. datum
Crest of spillway, elevation 2,258 feet

Capacity of reservoir, 60,100 acre-feet
Capacity of spillway, 73,000 second-feet

Dam:					
Excavation—					
Gravel—wet	94,500 cu. yds. at		$1 50	$141,800	
Common—dry	40,100 cu. yds. at		0 40	16,000	
Rock—wet	21,800 cu. yds. at		3 50	76,300	
Dry	63,400 cu. yds. at		2 50	158,500	
Cut-off trench	2,220 cu. yds. at		6 00	13,300	
					$405,900
Concrete—					
Mass	516,900 cu. yds. at		$6 00	$3,101,400	
Reinforced—parapets	330 cu. yds. at		17 25	5,690	
Gate towers and house	120 cu. yds. at		17 25	2,070	
					3,109,160
Grouting, drainage and seals	660 ft. of dam at		$90 00	$59,400	
					59,400
Outlets—					
Steel pipe—36-inch	210 ft.	at	$13 50	$2,840	
Trash racks	1,500 lbs.	at	0 10	150	
Roller gates—4' x 4'	2	at	6,000 00	12,000	
Needle valves—36-inch	2	at	14,300 00	28,600	
					43,590
Backfill	53,000 cu. yds. at		$0 25	$13,300	
					13,300
Spillway (shaft and tunnel type):					
Excavation—					
Inlet	35,180 cu. yds. at		$2 50	$88,000	
Shaft	10,740 cu. yds. at		8 00	85,900	
Tunnel	12,960 cu. yds. at		6 50	84,200	
Weir	16,880 cu. yds. at		2 50	42,200	
					300,300
Concrete—					
Mass—weir	14,280 cu. yds. at		$9 50	$135,700	
Reinforced—paving	710 cu. yds. at		14 50	10,300	
Shaft and tunnel lining	3,750 cu. yds. at		20 25	75,900	
					221,900
Reservoir[1]:					
Land			No cost		
Transmission line	2.8 mi.	at	$25,000 00	$70,000	
Clearing—brush	260 acres	at	20 00	5,200	
Trees	50 acres	at	50 00	2,500	
					77,700
Sub-total					$4,231,250
Administration, engineering and contingencies, 25%					1,057,810
Interest during construction—6% rate—2-year period					663,780
TOTAL COST					$5,952,840

[1] Does not include cost of relocation of State highway.

TABLE 86

COST OF SPRING CREEK RESERVOIR ON PIRU CREEK

With 187-foot Rock Fill Dam

Crest of dam, elevation 2,182 feet, U. S. G. S. datum
Crest of spillway, elevation 2,160 feet

Capacity of reservoir, 20,200 acre-feet
Capacity of spillway, 73,000 second-feet

Dam:					
Diversion of stream—					
Excavation—					
Open cut	7,460 cu. yds. at		$2 50	$18,700	
Tunnel	8,420 cu. yds. at		6 50	54,700	
Concrete—					
Reinforced—tunnel lining	2,260 cu. yds. at		20 25	45,800	
Mass—tunnel plug	760 cu. yds. at		8 50	6,460	
					$125,660
Excavation—					
Gravel and talus	191,500 cu. yds. at		$0 50	$95,800	
Rock—dry	53,400 cu. yds. at		2 50	133,500	
Cut-off trench	3,100 cu. yds. at		6 00	18,600	
					247,900
Rockfill—					
Dumped	564,300 cu. yds. at		$1 50	$846,500	
Placed	67,000 cu. yds. at		3 25	217,800	
					1,064,300
Concrete—					
Mass—cut-off wall	6,900 cu. yds. at		$8 50	$58,700	
Reinforced—subslab	5,340 cu. yds. at		14 50	77,400	
Laminated slab	5,620 cu. yds. at		16 75	94,100	
Parapets	120 cu. yds. at		17 25	2,070	
Crest paving	270 cu. yds. at		14 50	3,920	
					236,190
Grouting cut-off	490 ft. of dam at		$125 00	$61,300	61,300
Backfill	60,300 cu. yds. at		0 25	$15,100	15,100
Spillway (side-channel type):					
Excavation—waste	602,000 cu. yds. at		$1 00	$602,000	
Reinforced concrete lining	8,400 cu. yds. at		16 00	134,400	
					736,400
Outlet:					
Steel pipe—60-inch	530 ft.	at	$22 50	$11,900	
Trash racks	1,500 lbs.	at	0 10	150	
Slide gate—4′ x 5′	1	at	6,700 00	6,700	
Needle valve—60-inch	1	at	14,200 00	14,200	
					32,950
Reservoir[1]:					
Land			No cost		
Transmission line	0.75 mi.	at	$25,000 00	$18,800	
Clearing—brush	148 acres	at	20 00	2,960	
Trees	30 acres	at	50 00	1,500	
					23,260
Sub-total					$2,543,060
Administration, engineering and contingencies, 25%					635,800
Interest during construction—6% rate—2-year period					399,000
TOTAL COST					$3,577,860

[1] Does not include cost of relocation of State highway.

TABLE 87

COST OF BLUE POINT RESERVOIR ON PIRU CREEK

With 165-foot Earth Fill Dam

Crest of dam, elevation 1,280 feet (1,235 U. S. G. S. datum) Capacity of reservoir, 20,000 acre-feet
Crest of spillway, elevation 1,255 feet Capacity of spillway, 98,000 second-feet

Dam:				
Diversion of stream—				
Excavation—				
Open cut	21,300 cu. yds. at	$1 50	$32,000	
Tunnel	14,200 cu. yds. at	6 50	92,300	
Concrete—				
Reinforced tunnel lining	3,450 cu. yds. at	$20 25	69,900	
Mass—tunnel plug	730 cu. yds. at	10 00	7,300	
				$201,500
Excavation				
Gravel	458,500 cu. yds. at	$0 50	$229,300	
Rock—stripping	122,200 cu. yds. at	1 50	183,300	
Cut-off trench	16,700 cu. yds. at	3 50	58,500	
Toe-wall trench	220 cu. yds. at	6 00	1,300	
				472,400
Earth fill—				
Impervious	1,124,300 cu. yds. at	$0 40	$449,700	
Pervious[2]	270,400 cu. yds. at	0 35	94,600	
				544,300
Concrete facing—				
Reinforced—slab	4,750 cu. yds. at	$15 50	$73,600	
Toe-wall	220 cu. yds. at	13 75	3,000	
				76,600
Backfill[1]	94,200 cu. yds. at	$0 25	$23,600	
				23,600
Spillway:				
Excavation—				
Gravel	21,300 cu. yds. at	$0 50	$10,600	
Rock—channel	1,100,000 cu. yds. at	1 00	1,100,000	
Cut-off wall	240 cu. yds. at	6 00	1,400	
Concrete—				
Reinforced—lining	9,930 cu. yds. at	16 00	158,900	
Cut-off wall	240 cu. yds. at	13 75	3,300	
				1,274,200
Outlet:				
Steel pipe—60-inch	1,100 feet at	$22 50	$24,800	
Concrete shell for pipe	110 cu. yds. at	10 00	1,100	
Backfill	7,760 cu. yds. at	0 25	1,900	
Concrete trash rack structure	10 cu. yds. at	22 50	200	
Trash rack	1,500 lbs. at	0 10	200	
Slide gate—4' x 5'	1 at	6,000 00	6,000	
Needle valve—60-inch	1 at	12,700 00	12,700	
				46,900
Reservoir:				
Lands and improvements			$4,500	
Clearing—brush	190 acres at	$20 00	3,800	
Trees	40 acres at	50 00	2,000	
				10,300
Sub-total				$2,649,800
Administration, engineering and contingencies, 25%				662,500
Interest during construction—6% rate—1-year period				201,700
TOTAL COST				$3,514,000

[1] Includes cut-off trench backfill.
[2] Assumed 35% of material required would be obtained from excavation.

TABLE 88

COST OF DEVIL CANYON RESERVOIR ON PIRU CREEK

With 185-foot Earth Fill Dam

Crest of dam, elevation 1,220 feet (1,175 feet U. S. G. S. datum)
Crest of spillway, elevation 1,195 feet

Capacity of reservoir, 41,300 acre-feet
Capacity of spillway, 105,000 second-feet

Dam:				
Diversion of stream—				
Excavation—				
Open cut	176,000 cu. yds. at	$1 50	$26,400	
Tunnel	18,120 cu. yds. at	6 50	117,800	
Concrete—				
Reinforced—tunnel lining	4,430 cu. yds. at	20 25	89,700	
Mass—tunnel plug	730 cu. yds. at	10 00	7,300	
				$241,200
Excavation—				
Gravel	708,500 cu. yds. at	$0 50	$354,250	
Rock—stripping	56,200 cu. yds. at	1 50	84,300	
Cut-off trench	9,000 cu. yds. at	3 50	31,500	
Toe-wall trench	260 cu. yds. at	6 00	1,560	
				471,610
Earth fill—				
Impervious[1]	2,142,000 cu. yds. at	$0 40	$856,800	
Pervious[2]	468,600 cu. yds. at	0 35	164,010	
				1,020,810
Concrete facing—				
Reinforced—slab	4,000 cu. yds. at	$15 50	$62,000	
Toe-wall	260 cu. yds. at	13 75	3,580	
				65,580
Backfill	92,700 cu. yds. at	$0 25	$23,200	
				23,200
Spillway:				
Excavation—				
Gravel	2,200 cu. yds. at	$0 50	$1,100	
Rock—channel	820,000 cu. yds. at	1 00	820,000	
Cut-off trench	520 cu. yds. at	6 00	3,120	
Concrete—				
Reinforced—lining	11,780 cu. yds. at	16 00	188,500	
Cut-off wall	610 cu. yds. at	13 75	8,380	
				1,021,000
Outlet:				
Steel pipe—60-inch	1,400 ft. at	$22 50	$31,500	
Concrete shell for pipe	120 cu. yds. at	10 00	1,200	
Backfill	8,960 cu. yds. at	0 25	2,240	
Concrete trash rack structure	10 cu. yds. at	22 50	200	
Trash rack	1,500 lbs. at	0 10	200	
Slide gate—4′ x 5′	1 at	6,860 00	6,860	
Needle valve—60-inch	1 at	14,600 00	14,600	
				56,800
Reservoir:				
Lands and improvements			$14,500	
Clearing—brush	290 acres at	$20 00	5,800	
Trees	29 acres at	50 00	1,500	
				21,800
Sub-total				$2,922,000
Administration, engineering and contingencies, 25%				730,500
Interest during construction—6% rate—1½-year period				338,600
TOTAL COST				$3,991,100

[1] Includes cut-off trench backfill.
[2] Assumed 35% of material required would be obtained from excavation.

TABLE 89

COST OF COLD SPRING RESERVOIR ON SESPE CREEK

With 215-foot Earth Fill Dam

Crest of dam, elevation 3,425 feet (assumed datum)
Crest of spillway, elevation 3,400 feet

Capacity of reservoir, 42,990 acre-feet
Capacity of spillway, 23,500 second-feet

Dam:					
Diversion of stream—					
Excavation—					
Open cut	4,000 cu. yds.	at	$1 50	$6,000	
Tunnel	5,530 cu. yds.	at	10 00	55,300	
Concrete—					
Reinforced—tunnel lining	2,200 cu. yds.	at	23 75	52,300	
Head-walls and paving	530 cu. yds.	at	19 50	10,300	
Mass—tunnel plug	285 cu. yds.	at	13 50	3,850	
					$127,750
Excavation—					
Common	321,200 cu. yds.	at	$0 50	$160,600	
Rock—cut-off trench	34,200 cu. yds.	at	3 50	119,700	
Toe-wall trench	220 cu. yds.	at	5 00	1,110	
					281,410
Earth fill—					
Impervious	1,190,000 cu. yds.	at	$0 40	$476,000	
Pervious[1]	702,000 cu. yds.	at	0 35	245,700	
					721,700
Concrete facing—					
Reinforced—slab	5,780 cu. yds.	at	$19 00	$109,800	
Toe-wall	220 cu. yds.	at	17 25	3,800	
					113,600
Backfill	11,100 cu. yds.	at	$0 25	$2,780	
					2,780
Spillway:					
Excavation—					
Rock—loose	52,600 cu. yds.	at	$1 50	$78,900	
Cut-off trench	70 cu. yds.	at	5 00	350	
					79,250
Concrete—					
Reinforced—lining	2,460 cu. yds.	at	$19 50	$48,000	
Cut-off wall	70 cu. yds.	at	16 50	1,160	
					49,160
Outlet:					
Steel pipe—60-inch	970 ft.	at	$22 50	$21,800	
Concrete trash rack structure	10 cu. yds.	at	26 00	260	
Trash racks	1,500 lbs.	at	0 10	150	
Slide gate—4′ x 5′	1	at	7,500 00	7,500	
Needle valve—60-inch	1	at	15,900 00	15,900	
					45,610
Reservoir:					
Land and improvements				$4,000	
Clearing—brush	350 acres	at	$20 00	7,000	
Trees	35 acres	at	50 00	1,750	
					12,750
Construction road	2 mi.	at	7,500 00	15,000	
					15,000
Sub-total					$1,449,010
Administration, engineering and contingencies, 25%					362,250
Interest during construction—6% rate—1½-year period					167,900
TOTAL COST					$1,979,160

[1] After deducting 186,000 cubic yards placed in fill from stripping.

TABLE 90

COST OF TOPA TOPA RESERVOIR ON SESPE CREEK

With 240-foot Rock Fill Dam

Crest of dam, elevation 2,325 feet (2,381 feet, U. S. G. S. datum)
Crest of spillway, elevation 2,300 feet

Capacity of reservoir, 23,800 acre-feet
Capacity of spillway, 53,000 second-feet

Dam:				
Diversion of stream—				
Excavation—				
Open cut	3,670 cu. yds. at	$1 50	$5,500	
Tunnel	6,950 cu. yds. at	8 00	55,600	
Cut-off trench	70 cu. yds. at	6 00	420	
				$61,520
Concrete—				
Reinforced—tunnel lining	2,320 cu. yds. at	$23 50	$54,500	
Head-walls, etc.	310 cu. yds. at	22 25	6,900	
Mass—tunnel plug	450 cu. yds. at	13 25	5,960	
				67,360
Excavation—				
Gravel	151,400 cu. yds. at	$0 50	$75,700	
Rock—stripping	40,100 cu. yds. at	2 50	100,300	
Cut-off trench	1,890 cu. yds. at	6 00	11,300	
				187,300
Rockfill—				
Dumped	929,500 cu. yds. at	$1 50	$1,394,200	
Placed	80,700 cu. yds. at	3 25	262,300	
				1,656,500
Concrete—				
Mass—cut-off wall	1,890 cu. yds. at	$12 75	$24,100	
Reinforced—subslab	8,020 cu. yds. at	18 25	146,400	
Laminated slab	8,010 cu. yds. at	20 50	164,200	
Parapets	130 cu. yds. at	21 00	2,730	
Crown paving	280 cu. yds. at	18 25	5,110	
				342,540
Grouting cut-off	500 ft. of dam at	$100 00	$50,000	
				50,000
Backfill	6,000 cu. yds. at	$0 25	$1,500	
				1,500
Spillway (side-channel type):				
Excavation—				
Rock—cut-off trench	200 cu. yds. at	$6 00	$1,200	
Waste	270,500 cu. yds. at	1 00	270,500	
				271,700
Concrete—				
Reinforced—lining	6,460 cu. yds. at	$19 25	$124,400	
Cut-off wall	200 cu. yds. at	16 50	3,300	
				127,700
Outlet:				
Steel pipe—60-inch	830 ft. at	$22 50	$18,700	
Trash rack structure	10 cu. yds. at	25 75	260	
Trash rack	1,500 lbs. at	0 10	150	
Slide gate—4′ x 5′	1 at	7,700 00	7,700	
Needle valve—60-inch	1 at	16,400 00	16,400	
				43,210
Reservoir:				
Land and improvements			$400	
Clearing—brush	150 acres at	$20 00	3,000	
Trees	30 acres at	50 00	1,500	
				4,900
Construction road	10.5 mi. at	$20,000 00	$210,000	
				210,000
Sub-total				$3,024,230
Administration, engineering and contingencies, 25%				756,060
Interest during construction—6% rate—2-year period				474,430
TOTAL COST				$4,254,720

TABLE 91

COST OF MATILIJA RESERVOIR ON MATILIJA CREEK

With 170-foot Rock Fill Dam

Crest of dam, elevation 1,155 feet, U. S. G. S. datum
Crest of spillway, elevation 1,130 feet

Capacity of reservoir, 8,150 acre-feet
Capacity of spillway, 27,000 second-feet

Dam:				
Diversion of stream—				
Excavation—				
Open cut	3,440 cu. yds. at	$1 50	$5,160	
Tunnel	2,160 cu. yds. at	11 50	24,800	
Concrete—				
Reinforced—tunnel lining	660 cu. yds. at	21 75	14,400	
Mass—tunnel plug	200 cu. yds. at	11 75	2,350	
				$46,710
Excavation—				
Common	53,500 cu. yds. at	$0 50	$26,800	
Rock—stripping	41,700 cu. yds. at	2 50	104,300	
Cut-off trench	3,260 cu. yds. at	6 00	19,600	
				150,700
Rockfill:				
Dumped	476,000 cu. yds. at	$1 50	$714,000	
Placed	62,300 cu. yds. at	3 25	202,500	
				916,500
Backfill	3,890 cu. yds. at	$0 25	$970	
				970
Concrete—				
Mass—cut-off wall	3,260 cu. yds. at	$11 25	$36,700	
Reinforced—subslab	5,560 cu. yds. at	16 50	91,700	
Laminated slab	5,270 cu. yds. at	18 75	98,800	
Parapet	160 cu. yds. at	19 25	3,080	
Crown paving	360 cu. yds. at	16 50	5,940	
				236,220
Grouting cut-off	640 ft. of dam at	$125 00	$80,000	
				80,000
Spillway:				
Excavation	(1)			
Reinforced concrete lining	11,400 cu. yds. at	$17 50	$199,500	
				199,500
Outlet:				
Steel pipe—36-inch	715 lin. ft. at	$13 50	$9,650	
Trash rack structure	10 cu. yds. at	24 00	240	
Trash rack	1,590 lbs. at	0 10	150	
Concrete pipe cover	70 cu. yds. at	11 25	790	
Backfill	2,100 cu. yds. at	0 25	520	
Slide gate	1 at	5,850 00	5,850	
Needle valve	1 at	9,200 00	9,200	
				26,400
Reservoir:				
Land and improvements			$45,000	
Clearing	160 acres at	$20 00	3,200	
				48,200
Sub-total				$1,705,200
Administration, engineering and contingencies—25%				426,300
Interest during construction—6% rate—1½-year period				197,500
TOTAL COST				$2,329,000

[1] All excavation used in dam, assuming 50% waste.

TABLE 92

COST OF CAMARILLO RESERVOIR ON CONEJO CREEK

With 80-foot Earth Fill Dam

Crest of dam, elevation 235 feet, U. S. G. S. datum
Crest of spillway, elevation 215 feet

Capacity of reservoir, 8,280 acre-feet
Capacity of spillway, 10,000 second-feet

Dam:				
Excavation—				
Stripping dam base	2,020 cu. yds. at	$0 50	$1,000	
Toe-wall	180 cu. yds. at	0 50	100	
Core-wall	6,010 cu. yds. at	1 00	6,000	
				$7,100
Steel-sheet piling cut-off wall	155 tons at	$75 00	$11,600	
				11,600
Concrete—reinforced—				
Face-slab	2,460 cu. yds. at	$16 00	$39,400	
Toe-wall	180 cu. yds at	14 25	2,600	
Core-wall	2,860 cu. yds. at	16 00	45,800	
				87,800
Backfill—core-wall	5,300 cu. yds. at	$0 45	$2,400	
				2,400
Earth fill—				
Dam	281,300 cu. yds. at	$0 45	$126,600	
Highway	39,000 cu. yds. at	0 50	19,500	
				146,100
Spillway:				
Excavation	24,500 cu. yds. at	$1 00	$24,500	
Reinforced concrete—				
Lining	2,020 cu. yds. at	16 50	33,300	
Cut-off walls	270 cu. yds. at	15 00	4,100	
				61,900
Outlet:				
Reinforced concrete tower	120 cu. yds. at	$32 75	$3,900	
Trash racks	1,500 lbs. at	0 10	200	
Excavation for pipe	670 cu. yds. at	0 50	300	
Steel pipe—36-inch	450 feet at	13 50	6,100	
Concrete pipe cover and collars	330 cu. yds. at	10 50	3,500	
Backfill over pipe	340 cu. yds. at	0 45	200	
Slide gates—36-inch	2 at	3,000 00	6,000	
				20,200
Reservoir:				
Land and improvements			$271,400	
Clearing	20 acres at	$30 00	600	
				272,000
Sub-total				$609,100
Administration, engineering and contingencies, 25%				152,300
Interest during construction—6% rate—1-year period				46,600
TOTAL COST				$808,000

TABLE 93

COST OF DUNSHEE RESERVOIR ON COYOTE CREEK

With 120-foot Earth Fill Dam

Crest of dam, elevation 530 feet, U. S. G. S. datum
Crest of spillway, elevation 515 feet

Capacity of reservoir, 7,100 acre-feet
Capacity of spillway, 10,600 second-feet

Dam:				
Diversion of stream—				
Excavation—				
Open cut	2,400 cu. yds. at	$1 50	$3,600	
Tunnel	2,600 cu. yds. at	11 50	29,900	
Concrete—				
Reinforced—tunnel lining	1,390 cu. yds. at	22 00	30,600	
Head-walls	110 cu. yds. at	20 00	2,200	
Mass—tunnel plug	180 cu. yds. at	12 00	2,200	
				$68,500
Excavation—				
Stripping	128,000 cu. yds. at	$0 50	$64,000	
Rock—toe-wall trench	2,000 cu. yds. at	4 00	8,000	
				72,000
Earth fill—				
Impervious	435,000 cu. yds. at	$0 40	$174,000	
Pervious	194,000 cu. yds. at	0 35	67,900	
				241,900
Concrete-facing—				
Reinforced—slab	2,800 cu. yds. at	$17 25	$48,300	
Toe-wall	2,000 cu. yds. at	15 75	31,500	
				79,800
Spillway:				
Excavation—				
Open cut	6,800 cu. yds. at	$1 50	$10,200	
Concrete—				
Reinforced—paving	1,770 cu. yds. at	17 75	31,400	
				41,600
Outlet:				
Steel pipe—36-inch	700 ft. at	$8 65	$6,100	
Trash rack	3,000 lbs. at	0 10	300	
Slide gate—3′ x 3′	1 at	4,400 00	4,400	
Needle valve—36-inch	1 at	7,000 00	7,000	
				17,800
Earth dyke:				
Rolled fill	7,000 cu. yds. at	$0 40	$2,800	
Revetment	10,000 sq. ft. at	0 32	3,200	
				6,000
Reservoir:				
Land and improvements			$10,000	
Clearing	14 acres at	$100 00	1,400	
				11,400
Sub-total				$539,000
Administration, engineering and contingencies—25%				134,800
Interest during construction—6% rate—1-year period				41,000
TOTAL COST				$714,800

TABLE 94

DIVERSION CANAL, SANTA ANA CREEK TO DUNSHEE RESERVOIR

Capacity, 200 Second-feet; Length, 1.25 Miles

Right-of-way and clearing				$400
Excavation:				
	9,000 cu yds. rock at	$1 00	$9,000	
	14,400 cu. yds. earth at	0 25	3,600	
	2,330 lin. ft. concrete lining at	3 00	7,000	
				19,600
Dam and control works				7,000
BASE COST				$27,000
Engineering, administration and contingencies—25%				7,000
Interest during construction—rate 6%				1,000
TOTAL COST				$35,000

PUBLICATIONS

DIVISION OF WATER RESOURCES

PUBLICATIONS OF THE

DIVISION OF WATER RESOURCES

DEPARTMENT OF PUBLIC WORKS

STATE OF CALIFORNIA

When the Department of Public Works was created in July, 1921, the State Water Commission was succeeded by the Division of Water Rights, and the Department of Engineering was succeeded by the Division of Engineering and Irrigation in all duties except those pertaining to State Architect. Both the Division of Water Rights and the Division of Engineering and Irrigation functioned until August, 1929, when they were consolidated to form the Division of Water Resources.

STATE WATER COMMISSION

First report, State Water Commission, March 24 to November 1, 1912.
Second Report, State Water Commission, November 1, 1912, to April 1, 1914.
*Biennial Report, State Water Commission, March 1, 1915, to December 1, 1916.
Biennial Report, State Water Commission, December 1, 1916, to September 1, 1918.
Biennial Report, State Water Commission, September 1, 1918, to September 1, 1920.

DIVISION OF WATER RIGHTS

*Bulletin No. 1—Hydrographic Investigation of San Joaquin River, 1920–1923.
*Bulletin No. 2—Kings River Investigation, Water Master's Reports, 1918–1923.
*Bulletin No. 3—Proceedings First Sacramento-San Joaquin River Problems Conference, 1924.
*Bulletin No. 4—Proceedings Second Sacramento-San Joaquin River Problems Conference, and Water Supervisors' Report, 1924.
*Bulletin No. 5—San Gabriel Investigation—Basic Data, 1923–1926.
Bulletin No. 6—San Gabriel Investigation—Basic Data, 1926–1928.
Bulletin No. 7—San Gabriel Investigation—Analysis and Conclusions, 1929.
*Biennial Report, Division of Water Rights, 1920–1922.
*Biennial Report, Division of Water Rights, 1922–1924.
Biennial Report, Division of Water Rights, 1924–1926.
Biennial Report, Division of Water Rights, 1926–1928.

DEPARTMENT OF ENGINEERING

*Bulletin No. 1—Cooperative Irrigation Investigations in California, 1912–1914.
*Bulletin No. 2—Irrigation Districts in California, 1887–1915.
Bulletin No. 3—Investigations of Economic Duty of Water for Alfalfa in Sacramento Valley, California, 1915.
*Bulletin No. 4—Preliminary Report on Conservation and Control of Flood Waters in Coachella Valley, California, 1917.
*Bulletin No. 5—Report on the Utilization of Mohave River for Irrigation in Victor Valley, California, 1918.
*Bulletin No. 6—California Irrigation District Laws, 1919 (now obsolete).
Bulletin No. 7—Use of water from Kings River, California, 1918.
*Bulletin No. 8—Flood Problems of the Calaveras River, 1919.
Bulletin No. 9—Water Resources of Kern River and Adjacent Streams and Their Utilization, 1920.
*Biennial Report, Department of Engineering, 1907–1908.
*Biennial Report, Department of Engineering, 1908–1910.
*Biennial Report, Department of Engineering, 1910–1912.
*Biennial Report, Department of Engineering, 1912–1914.
*Biennial Report, Department of Engineering, 1914–1916.
*Biennial Report, Department of Engineering, 1916–1918.
*Biennial Report, Department of Engineering, 1918–1920.

* Reports and Bulletins out of print. These may be borrowed by your local library from the California State Library at Sacramento, California.

DIVISION OF WATER RESOURCES

Including Reports of the Former Division of Engineering and Irrigation

*Bulletin No. 1—California Irrigation District Laws, 1921 (now obsolete).
*Bulletin No. 2—Formation of Irrigation Districts, Issuance of Bonds, etc., 1922.
Bulletin No. 3—Water Resources of Tulare County and Their Utilization, 1922.
Bulletin No. 4—Water Resources of California, 1923.
Bulletin No. 5—Flow in California Streams, 1923.
Bulletin No. 6—Irrigation Requirements of California Lands, 1923.
*Bulletin No. 7—California Irrigation District Laws, 1923 (now obsolete).
*Bulletin No. 8—Cost of Water to Irrigators in California, 1925.
Bulletin No. 9—Supplemental Report on Water Resources of California, 1925.
*Bulletin No. 10—California Irrigation District Laws, 1925 (now obsolete).
Bulletin No. 11—Ground Water Resources of Southern San Joaquin Valley, 1927.
Bulletin No. 12—Summary Report on the Water Resources of California and a Coordinated Plan for Their Development, 1927.
Bulletin No. 13—The Development of the Upper Sacramento River, containing U. S. R. S. Cooperative Report on Iron Canyon Project, 1927.
Bulletin No. 14—The Control of Floods by Reservoirs, 1928.
*Bulletin No. 18—California Irrigation District Laws, 1927 (now obsolete).
*Bulletin No. 18—California Irrigation District Laws, 1929, Revision (now obsolete).
Bulletin No. 18-B—California Irrigation District Laws, 1931, Revision.
Bulletin No. 19—Santa Ana Investigation, Flood Control and Conservation (with packet of maps), 1928.
Bulletin No. 20—Kennett Reservoir Development, an Anaylsis of Methods and Extent of Financing by Electric Power Revenue, 1929.
Bulletin No. 21—Irrigation Districts in California, 1929.
Bulletin No. 21-A—Report on Irrigation Districts in California for the year 1929.
Bulletin No. 21-B—Report on Irrigation Districts in California for the year 1930.
Bulletin No. 21-C—Report on Irrigation Districts in California for the year 1931. (Mimeographed.)
Bulletin No. 21-D—Report on Irrigation Districts in California for the year 1932. (Mimeographed.)
Bulletin No. 22—Report on Salt Water Barrier (two volumes), 1929.
Bulletin No. 23—Report of Sacramento-San Joaquin Water Supervisor, 1924–1928.
Bulletin No. 24—A Proposed Major Development on American River, 1929.
Bulletin No. 25—Report to Legislature of 1931 on State Water Plan, 1930.
Bulletin No. 26—Sacramento River Basin, 1931.
Bulletin No. 27—Variation and Control of Salinity in Sacramento-San Joaquin Delta and Upper San Francisco Bay, 1931.
Bulletin No. 28—Economic Aspects of a Salt Water Barrier Below Confluence of Sacramento and San Joaquin Rivers, 1931.
Bulletin No. 28-A—Industrial Survey of Upper San Francisco Bay Area, 1930.
Bulletin No. 29—San Joaquin River Basin, 1931.
Bulletin No. 31—Santa Ana River Basin, 1930.
Bulletin No. 32—South Coastal Basin, a Cooperative Symposium, 1930.
Bulletin No. 33—Rainfall Penetration and Consumptive Use of Water in Santa Ana River Valley and Coastal Plain, 1930.
Bulletin No. 34—Permissible Annual Charges for Irrigation Water in Upper San Joaquin Valley, 1930.
Bulletin No. 35—Permissible Economic Rate of Irrigation Development in California, 1930.
Bulletin No. 36—Cost of Irrigation Water in California, 1930.
Bulletin No. 37—Financial and General Data Pertaining to Irrigation, Reclamation and Other Public Districts in California, 1930.
Bulletin No. 38—Report of Kings River Water Master for the Period 1918–1930.
Bulletin No. 39—South Coastal Basin Investigation, Records of Ground Water Levels at Wells, 1932.
Bulletin No. 40—South Coastal Basin Investigation, Quality of Irrigation Waters, 1933.
Bulletin No. 41—Pit River Investigation, 1933.
Bulletin No. 42—Santa Clara Investigation, 1933.

* Reports and Bulletins out of print. These may be borrowed by your local library from the California State Library at Sacramento, California.

Bulletin No. 43—Value and Cost of Water for Irrigation in Coastal Plain of Southern California, 1933.

Bulletin No. 44—Water Losses Under Natural Conditions from Wet Areas in Southern California, 1933.

Bulletin No. 46—Ventura County Investigation, 1933.

Biennial Report, Division of Engineering and Irrigation, 1920–1922.

Biennial Report, Division of Engineering and Irrigation, 1922–1924.

Biennial Report, Division of Engineering and Irrigation, 1924–1926.

Biennial Report, Division of Engineering and Irrigation, 1926–1928.

PAMPHLETS

Act Governing Supervision of Dams in California, with Revised Rules and Regulations, 1933.

Water Commission Act with Amendments Thereto, 1933.

Rules, Regulations and Information Pertaining to Appropriation of Water in California, 1933.

Rules and Regulations Governing the Determination of Rights to Use of Water in Accordance with the Water Commission Act, 1925.

Tables of Discharge for Parshall Measuring Flumes, 1928.

General Plans, Specifications and Bills of Material for Six and Nine Inch Parshall Measuring Flumes, 1930.

COOPERATIVE AND MISCELLANEOUS REPORTS

*Report of the Conservation Commission of California, 1912.

*Irrigation Resources of California and Their Utilization (Bul. 254, Office of Exp. U. S. D. A.) 1913.

*Report, State Water Problems Conference, November 25, 1916.

*Report on Pit River Basin, April, 1915.

*Report on Lower Pit River Project, July, 1915.

*Report on Iron Canyon Project, 1914.

*Report on Iron Canyon Project, California, May, 1920.

*Sacramento Flood Control Project (Revised Plans), 1925.

Report of Commission Appointed to Investigate Causes Leading to the Failure of St. Francis Dam, 1928.

Report of the California Joint Federal-State Water Resources Commission, 1930.

Conclusions and Recommendations of the Report of the California Irrigation and Reclamation Financing and Refinancing Commission, 1930.

*Report of California Water Resources Commission to the Governor of California on State Water Plan, 1932.

*Booklet of Information on California and the State Water Plan prepared for United States House of Representatives' Subcommittee on Appropriations, 1931.

*Bulletin on Great Central Valley Project of State Water Plan of California Prepared for United States Senate Committee on Irrigation and Reclamation, 1932.

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* Reports and Bulletins out of print. These may be borrowed by your local library from the California State Library at Sacramento, California.

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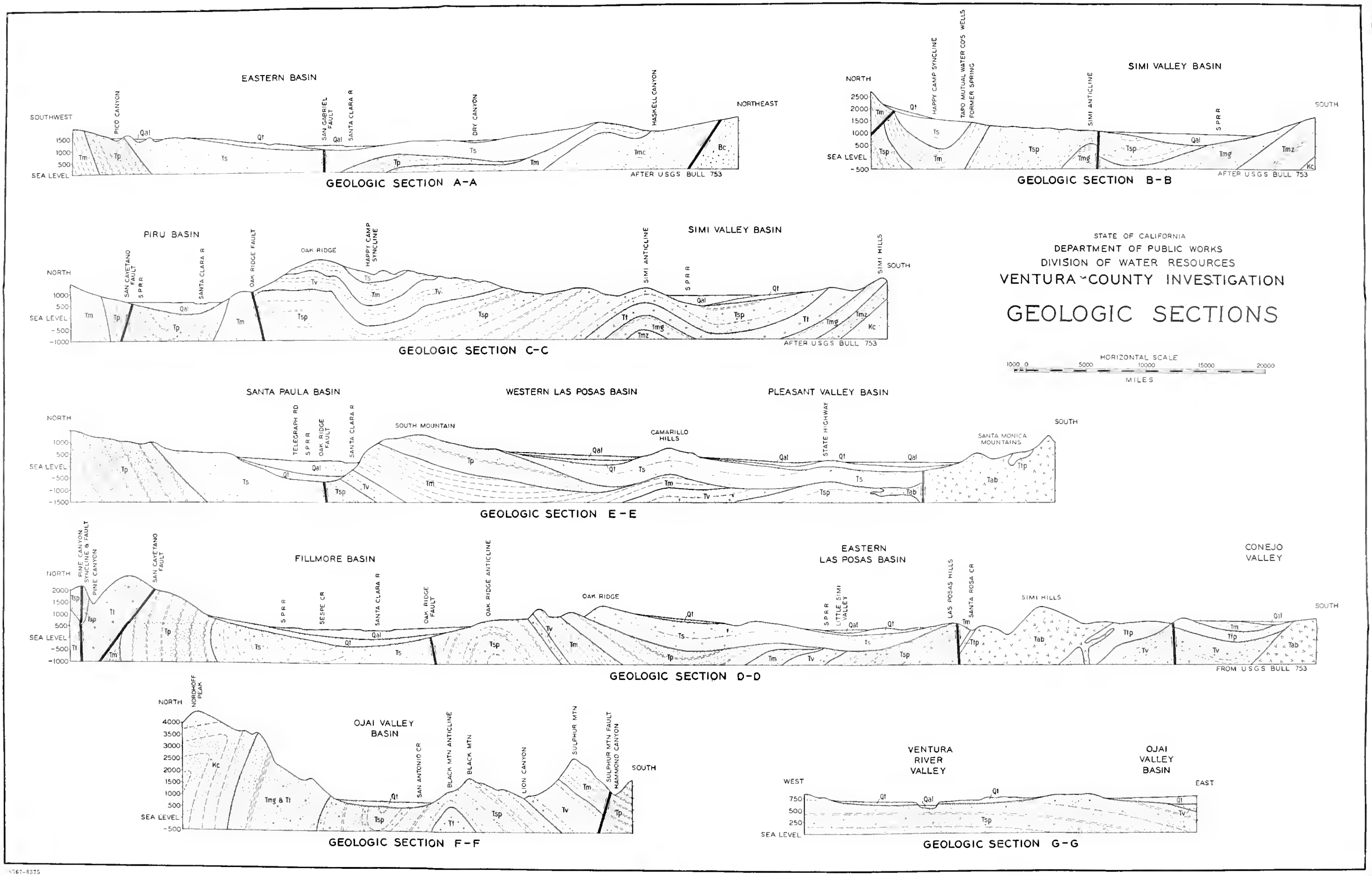
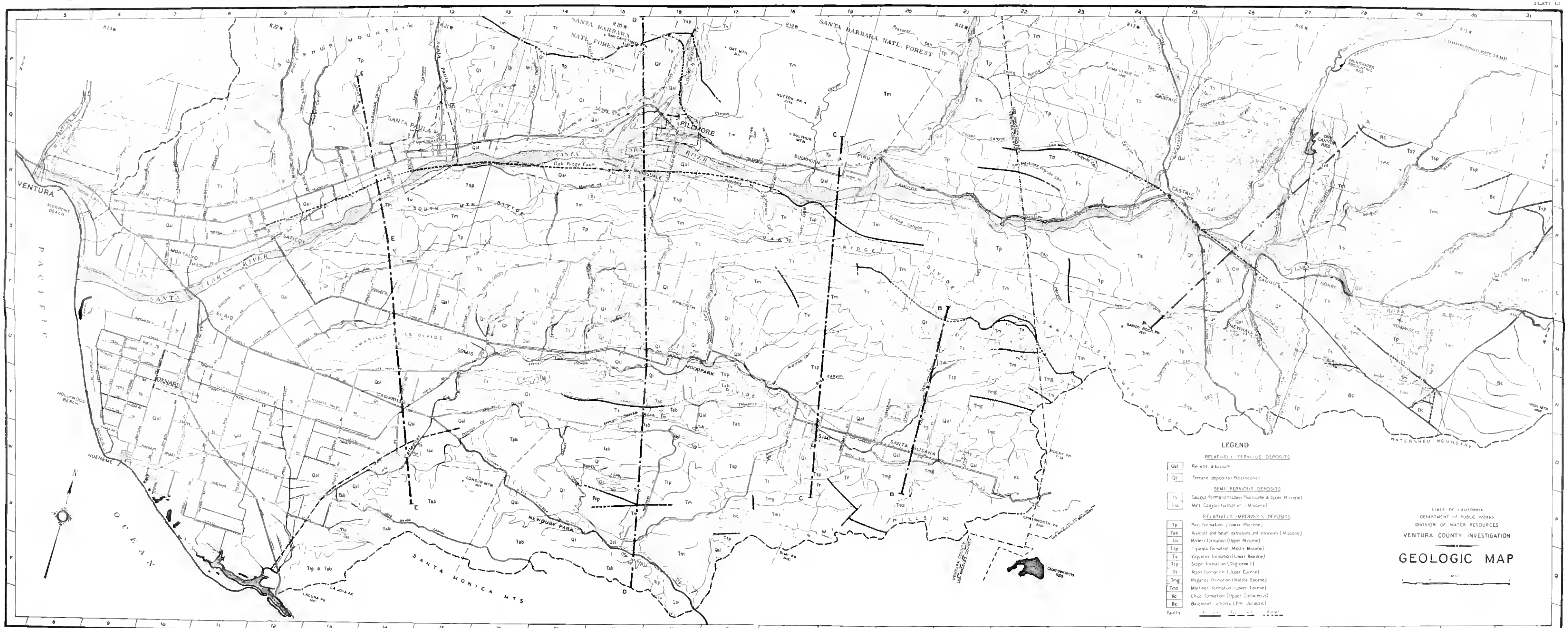
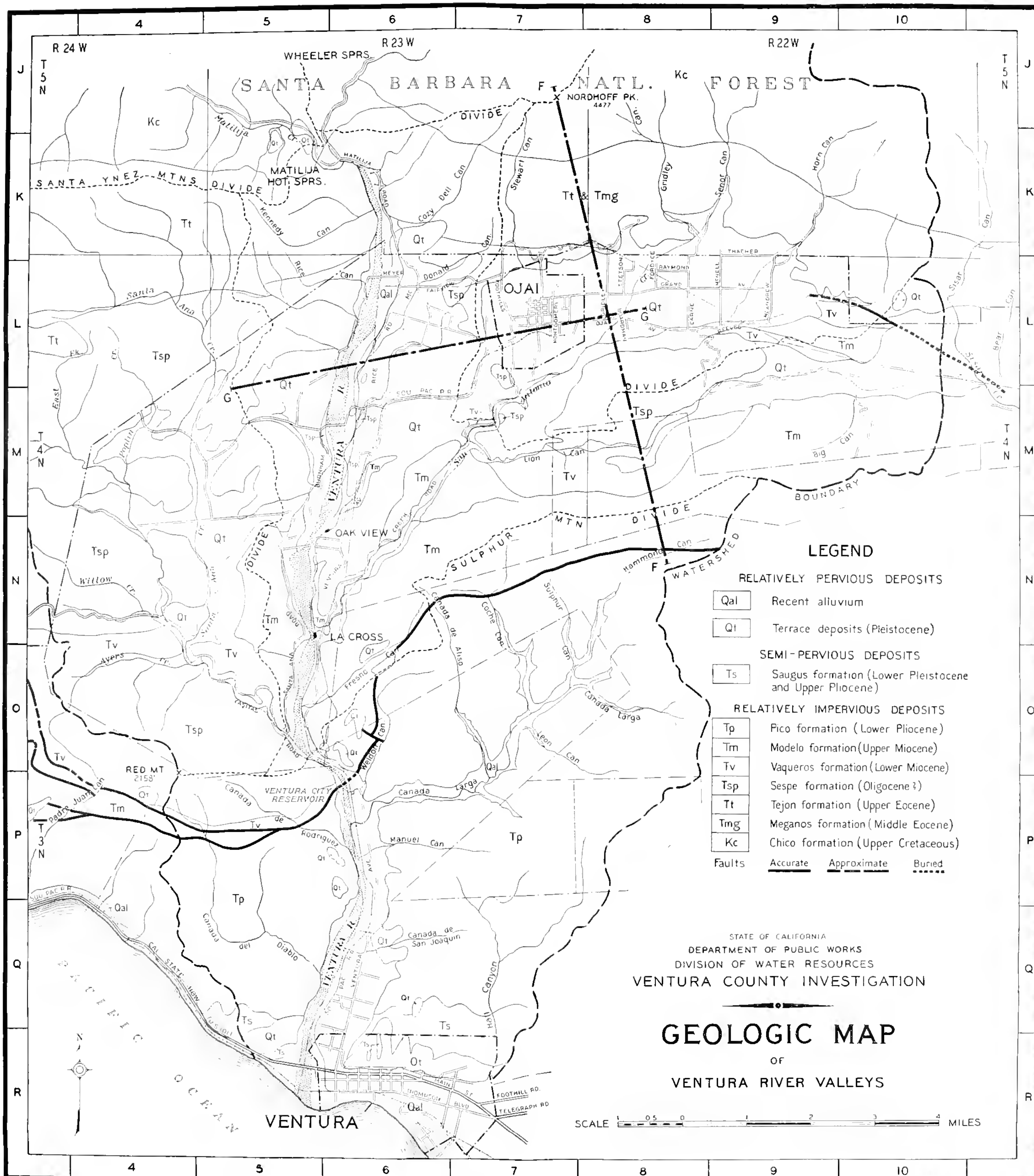

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
GEOLOGIC SECTIONS
HORIZONTAL SCALE
1000 0 5000 10000 15000 20000
MILES
EASTERN BASIN
SOUTHWEST
PICO CANYON
SAN GABRIEL FAULT
SANTA CLARA R
DRY CANYON
HASKELL CANYON
NORTHEAST
1500
1000
500
SEA LEVEL
AFTER USGS BULL 753
GEOLOGIC SECTION A-A
SIMI VALLEY BASIN
NORTH
HAPPY CAMP SYNCLINE
TAPO MUTUAL WATER CO'S WELLS
FORMER SPRING
SIMI ANTICLINE
S P R R
SOUTH
2500
2000
1500
1000
500
SEA LEVEL
-500
AFTER USGS BULL 753
GEOLOGIC SECTION B-B
PIRU BASIN
SAN CAYETANO FAULT
S P R R
SANTA CLARA R
OAK RIDGE FAULT
OAK RIDGE
HAPPY CAMP SYNCLINE
SIMI ANTICLINE
SIMI VALLEY BASIN
S P R R
SIMI HILLS
SOUTH
NORTH
1000
500
SEA LEVEL
-500
-1000
AFTER USGS BULL 753
GEOLOGIC SECTION C-C
SANTA PAULA BASIN
WESTERN LAS POSAS BASIN
PLEASANT VALLEY BASIN
NORTH
TELEGRAPH RD
S P R R
OAK RIDGE FAULT
SANTA CLARA R
SOUTH MOUNTAIN
CAMARILLO HILLS
STATE HIGHWAY
SANTA MONICA MOUNTAINS
SOUTH
1000
500
SEA LEVEL
-500
-1000
-1500
GEOLOGIC SECTION E-E
PINE CANYON SYNCLINE & FAULT
PINE CANYON
SAN CAYETANO FAULT
FILLMORE BASIN
S P R R
SESPE CR
SANTA CLARA R
OAK RIDGE FAULT
OAK RIDGE ANTICLINE
OAK RIDGE
EASTERN LAS POSAS BASIN
S P R R
LITTLE SIMI VALLEY
LAS POSAS HILLS
SANTA ROSA CR
SIMI HILLS
CONEJO VALLEY
NORTH
SOUTH
2000
1500
1000
500
SEA LEVEL
-500
-1000
FROM USGS BULL 753
GEOLOGIC SECTION D-D
NORTH
NORDHOFF PEAK
OJAI VALLEY BASIN
SAN ANTONIO CR
BLACK MTN ANTICLINE
BLACK MTN
LION CANYON
SULPHUR MTN
SULPHUR MTN FAULT
HAMMOND CANYON
SOUTH
4000
3500
3000
2500
2000
1500
1000
500
SEA LEVEL
-500
GEOLOGIC SECTION F-F
WEST
VENTURA RIVER VALLEY
OJAI VALLEY BASIN
EAST
750
500
250
SEA LEVEL
GEOLOGIC SECTION G-G

5367-8375

PLATE LI

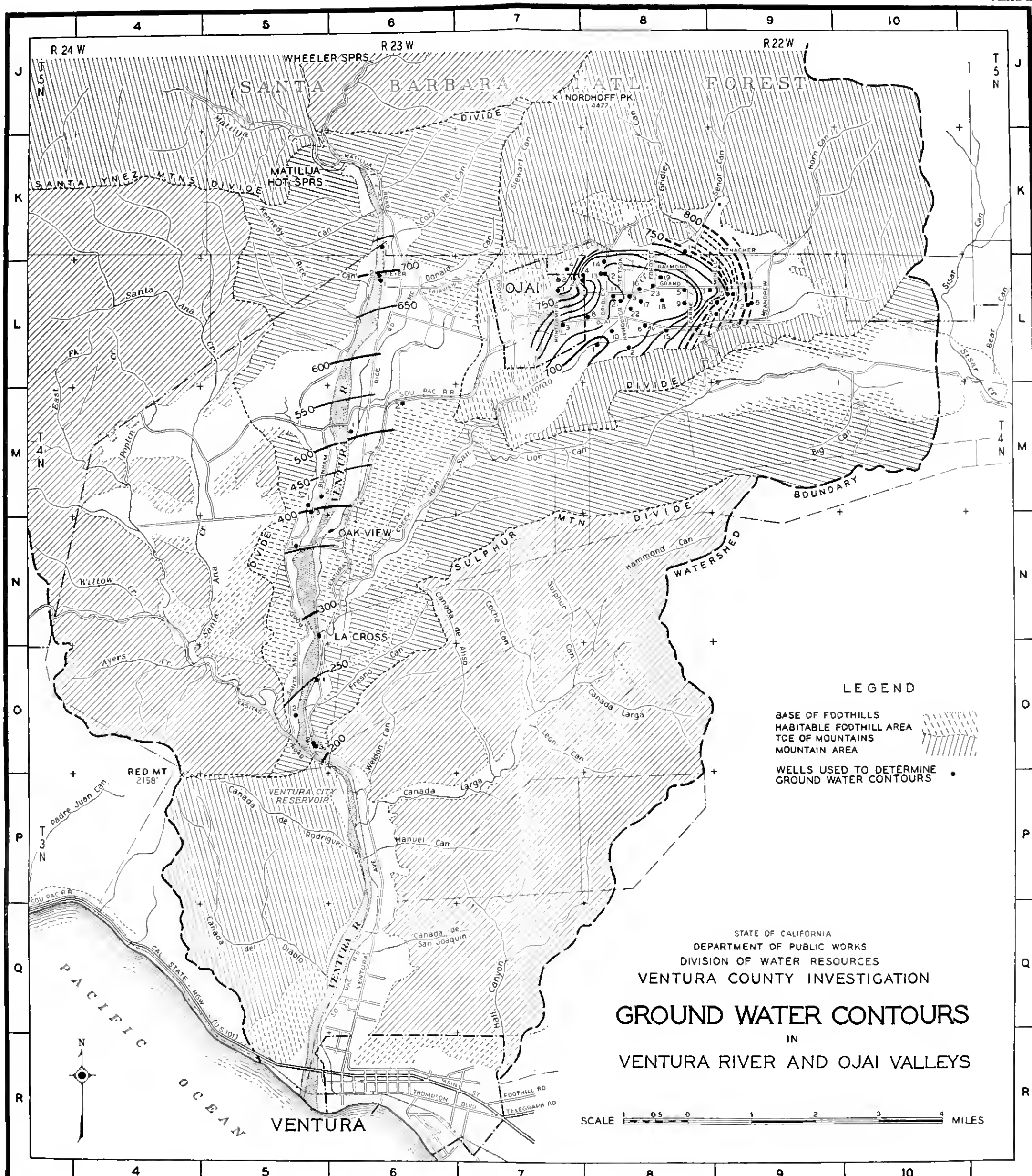


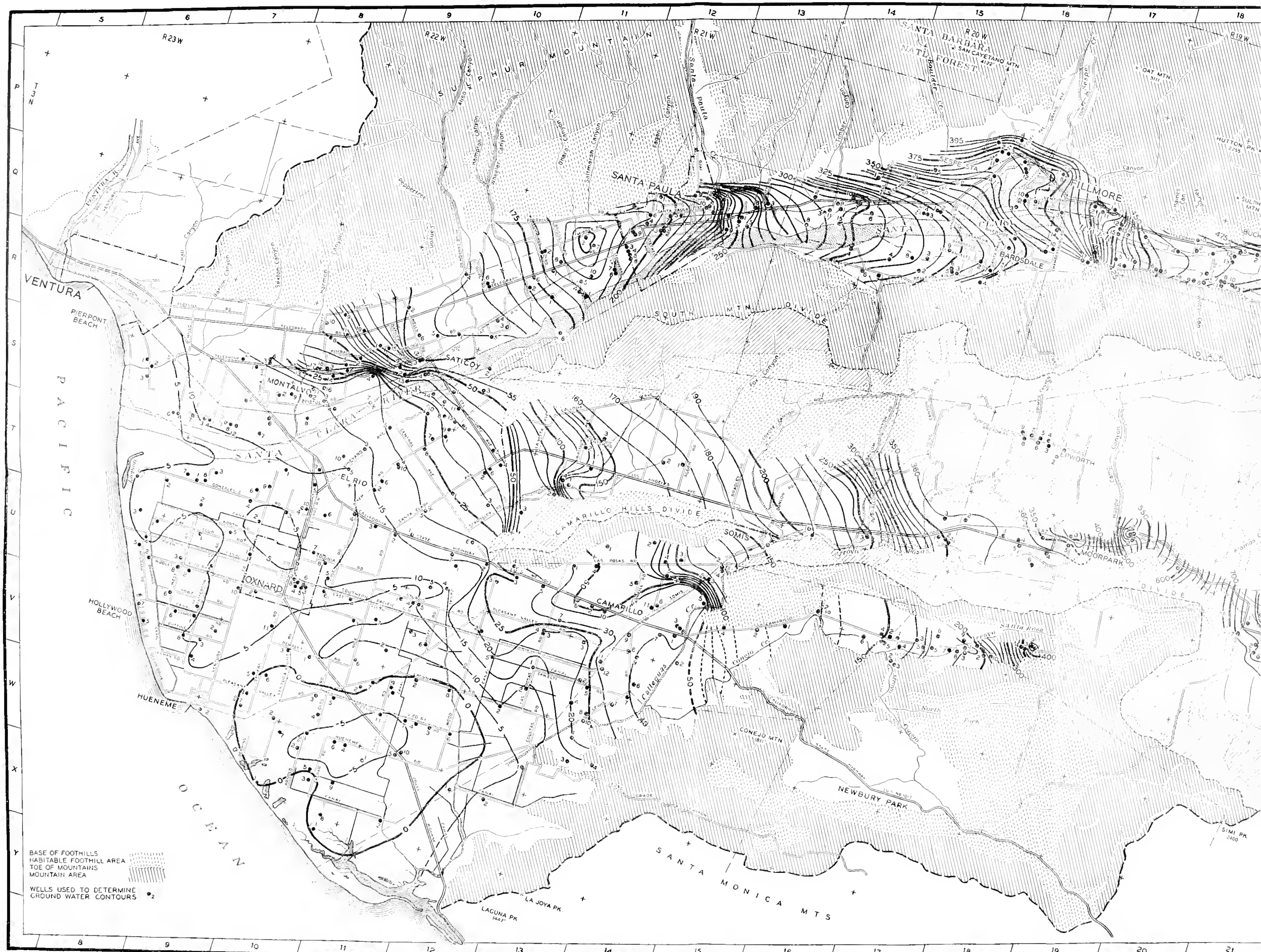
LEGEND
RELATIVELY PERVIOUS DEPOSITS
Qal Recent alluvium
Qt Terrace deposits (Pleistocene)
SEMI PERVIOUS DEPOSITS
Ts Saugus formation (Lower Pleistocene & Upper Pliocene)
Tmc Mint Canyon formation (Miocene)
RELATIVELY IMPERVIOUS DEPOSITS
Tp Pico formation (Lower Pliocene)
Tab Andesite and basalt extrusives and intrusives (Miocene)
Tm Modelo formation (Upper Miocene)
Ttp Topanga formation (Middle Miocene)
Tv Vaqueros formation (Lower Miocene)
Tsp Sespe formation (Oligocene ?)
Tt Tejon formation (Upper Eocene)
Tmg Meganos formation (Middle Eocene)
Tmz Martinez formation (Lower Eocene)
Kc Chico formation (Upper Cretaceous)
Bc Basement complex (Pre Jurassic)
Faults
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
GEOLOGIC MAP
VENTURA
OXNARD
HUENEME
SANTA PAULA
FILLMORE
SATICOY
MONTALVO
EL RIO
SOMIS
CAMARILLO
MOORPARK
SIMI
SANTA SUSANA
NEWHALL
SAUGUS
CASTAIC
CAMULOS
PIRU
BARDSDALE
NEWBURY PARK
PIERPONT BEACH
HOLLYWOOD BEACH
PACIFIC OCEAN
SANTA CLARA RIVER
SANTA BARBARA NATL. FOREST
SULPHUR MOUNTAIN
SANTA MONICA MTS
SANTA SUSANA MTS DIVIDE
SOUTH MTN DIVIDE
OAK RIDGE DIVIDE
CAMARILLO HILLS DIVIDE
SIMI HILLS
WATERSHED BOUNDARY
Oak Ridge Fault
CHATSWORTH RES
DRY CANYON RES



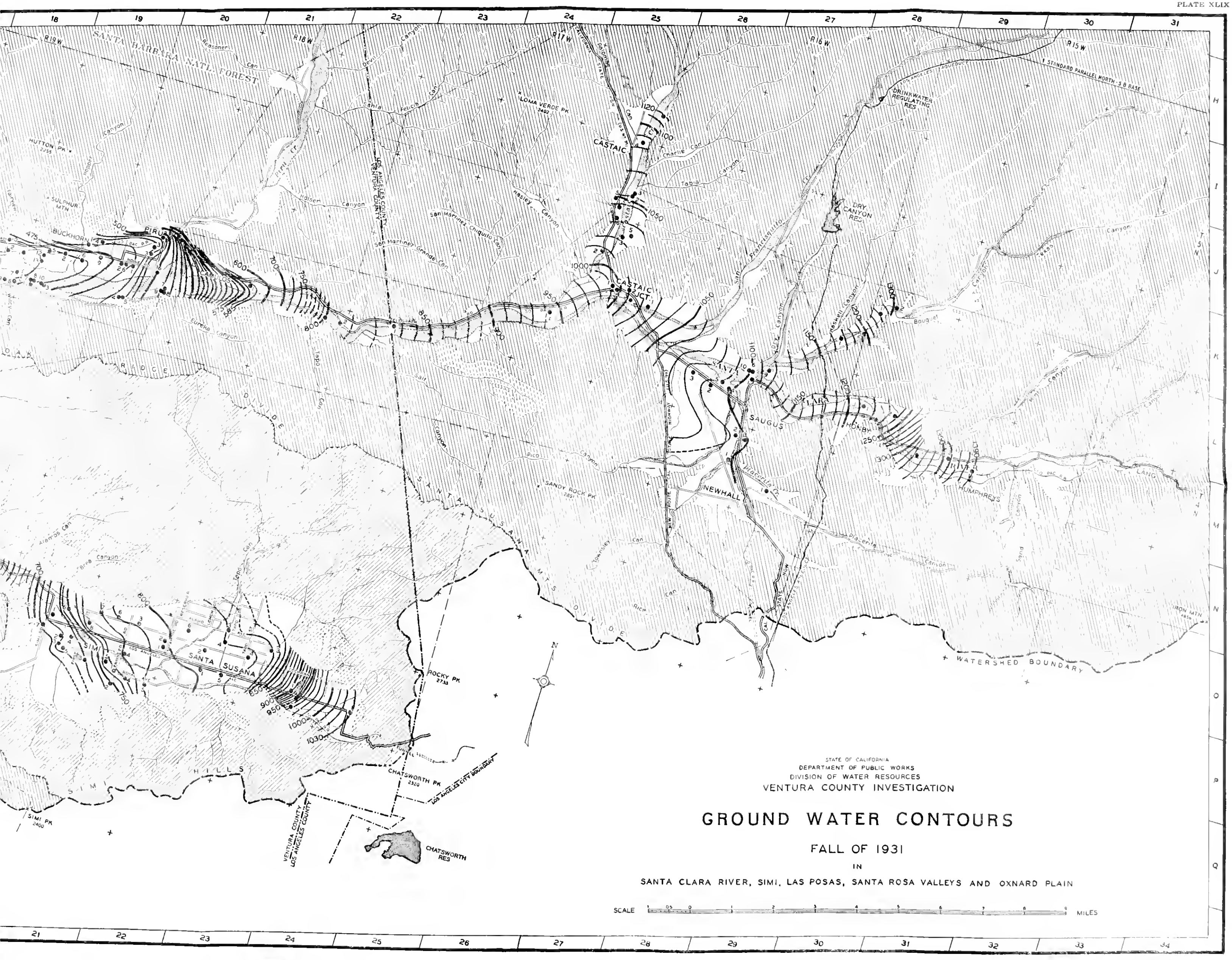
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION

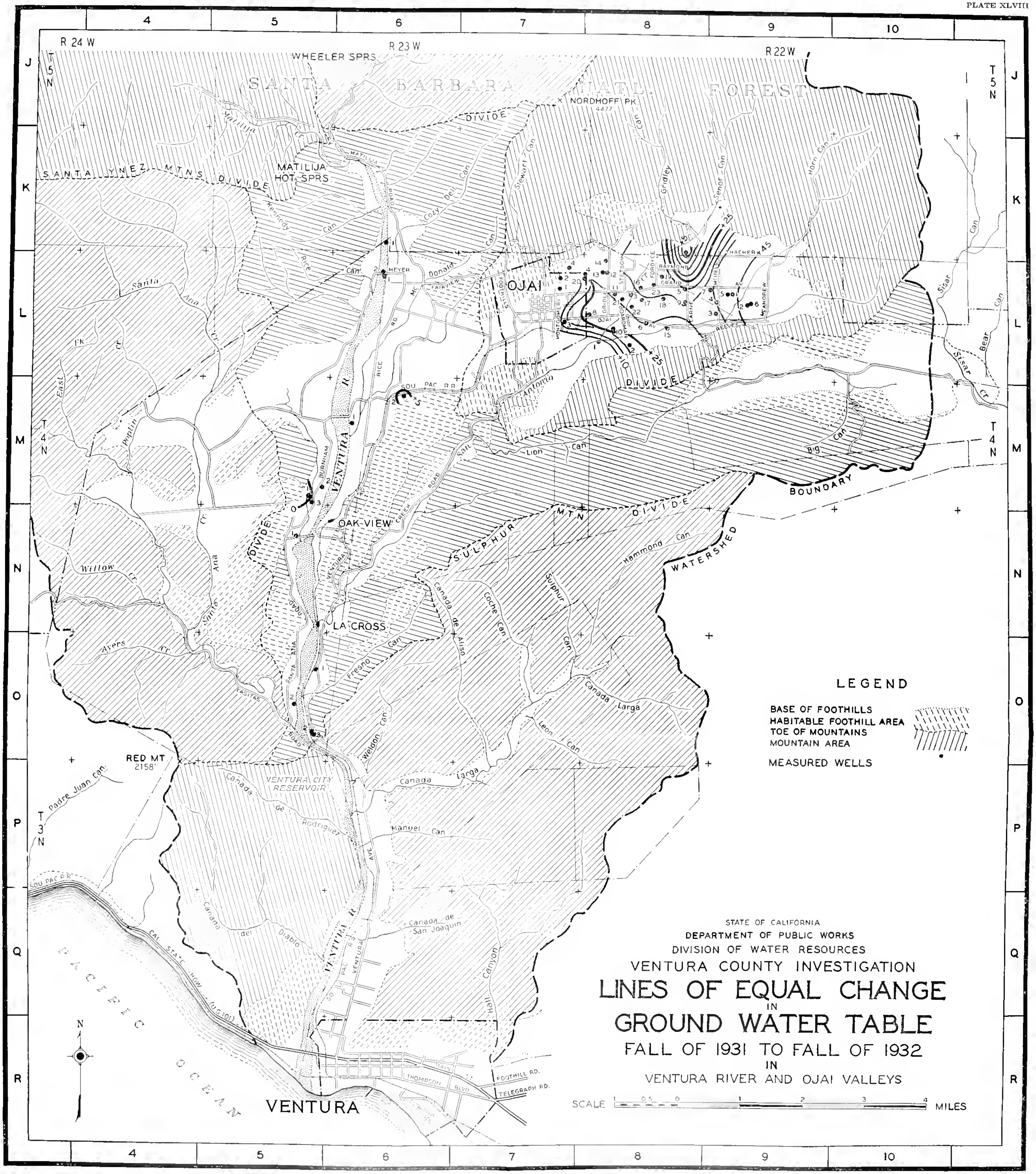
GEOLOGIC MAP
OF
VENTURA RIVER VALLEYS

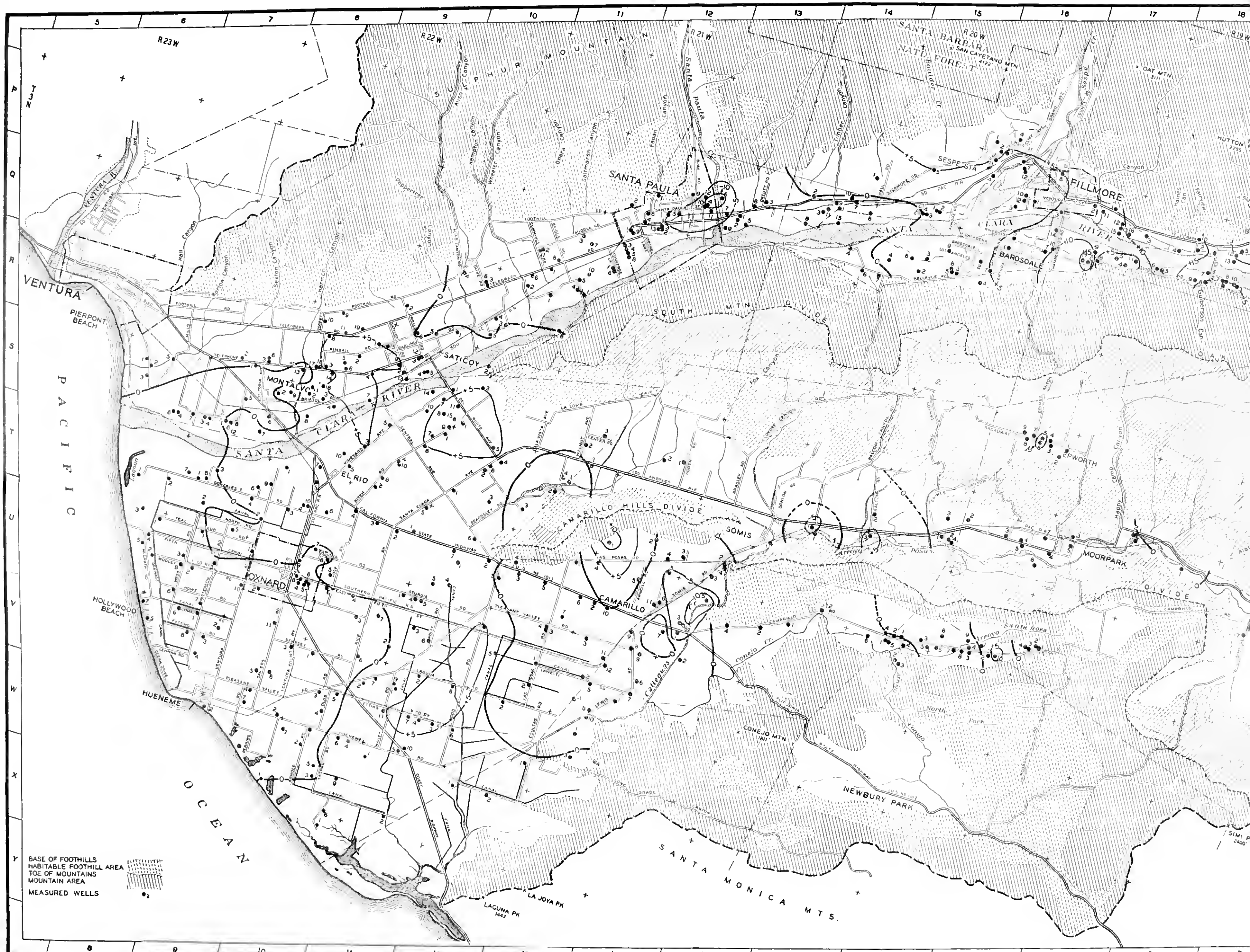

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
GROUND WATER CONTOURS
IN
VENTURA RIVER AND OJAI VALLEYS
LEGEND
BASE OF FOOTHILLS
HABITABLE FOOTHILL AREA
TOE OF MOUNTAINS
MOUNTAIN AREA
WELLS USED TO DETERMINE GROUND WATER CONTOURS
SCALE 1 0.5 0 1 2 3 4 MILES
R 24 W
R 23 W
R 22 W
T 5 N
T 4 N
T 3 N
SANTA BARBARA NATL. FOREST
WHEELER SPRS
NORDHOFF PK. 4477
MATILIJA HOT SPRS
SANTA YNEZ MTNS DIVIDE
OJAI
OAK VIEW
LA CROSS
RED MT 2158'
VENTURA CITY RESERVOIR
SULPHUR MTN DIVIDE
WATERSHED
BOUNDARY
PACIFIC OCEAN
VENTURA
800
750
700
650
600
550
500
450
400
300
250
200



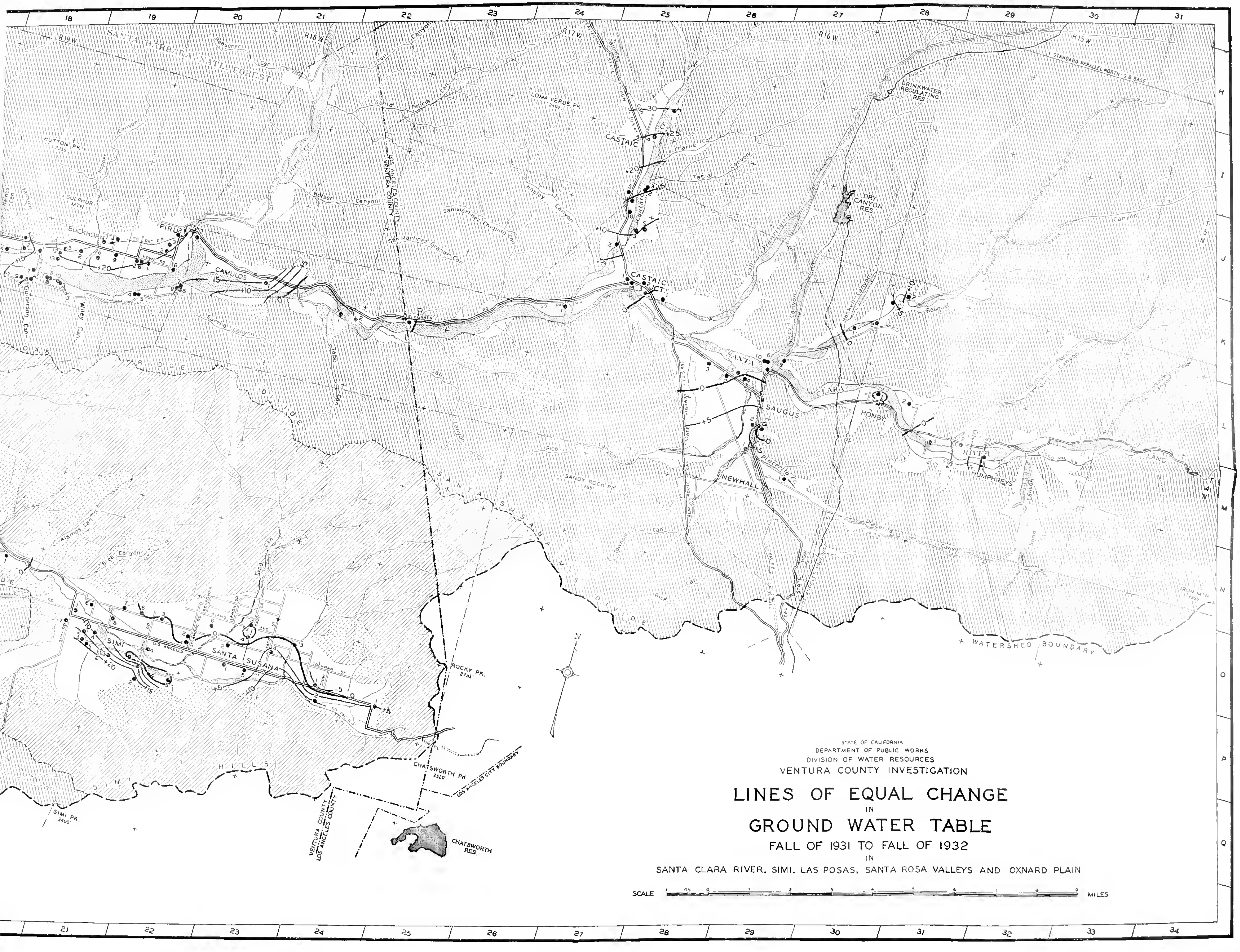
VENTURA
PIERPONT BEACH
PACIFIC OCEAN
HOLLYWOOD BEACH
HUENEME
OXNARD
EL RIO
MONTALVO
SATICOY
SANTA PAULA
FILLMORE
BARDSDALE
SOMIS
CAMARILLO
MOORPARK
NEWBURY PARK
SULPHUR MOUNTAIN
SANTA BARBARA NAT'L FOREST
SANTA MONICA MTS
SOUTH MTN DIVIDE
CAMARILLO HILLS DIVIDE
SANTA CLARA RIVER
CONEJO MTN
LAGUNA PK
LA JOYA PK.
R 23 W
R 22 W
R 21 W
R 20 W
R 19 W
T 3 N
BASE OF FOOTHILLS
HABITABLE FOOTHILL AREA
TOE OF MOUNTAINS
MOUNTAIN AREA
WELLS USED TO DETERMINE GROUND WATER CONTOURS

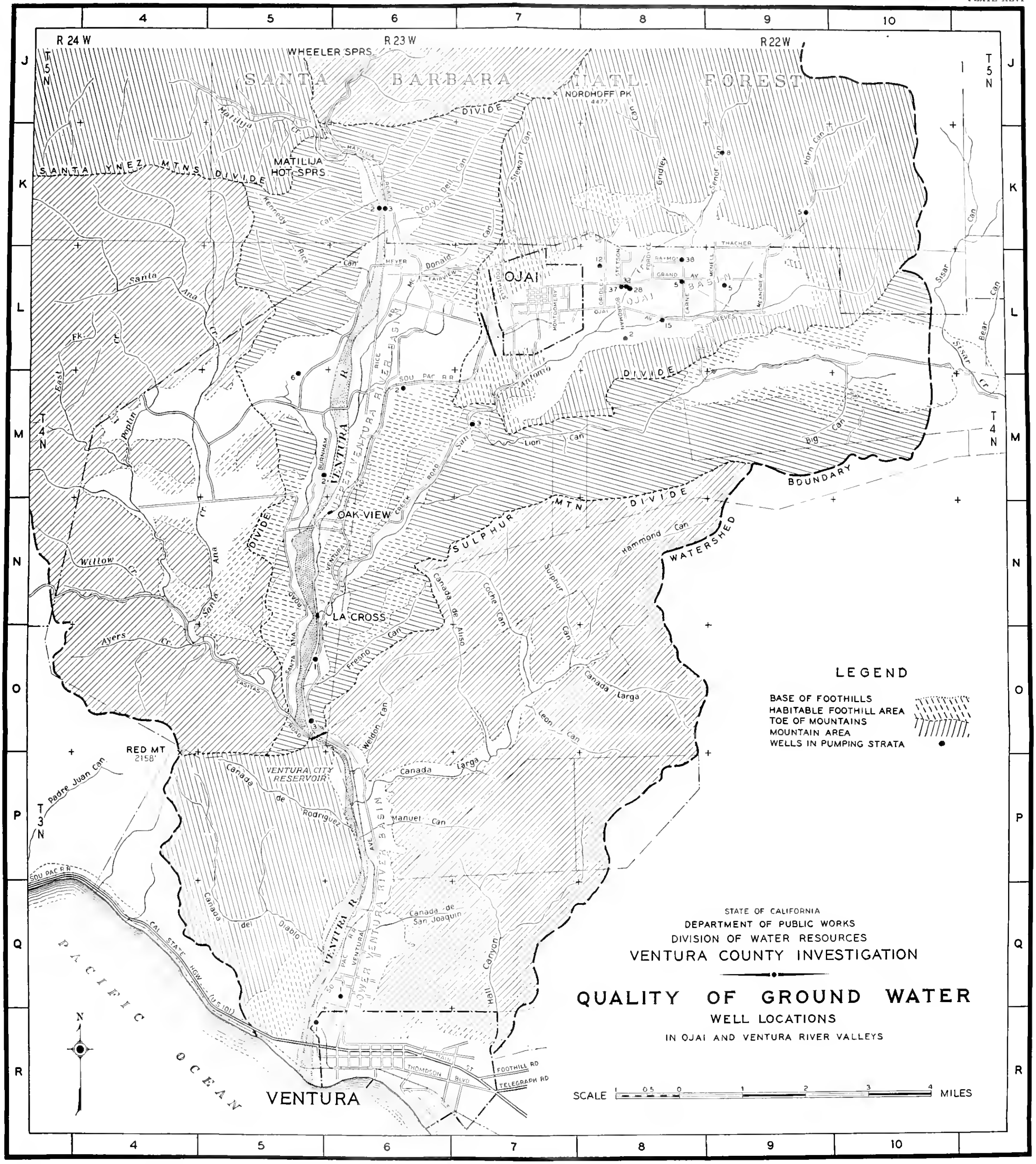

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
GROUND WATER CONTOURS
FALL OF 1931
IN
SANTA CLARA RIVER, SIMI, LAS POSAS, SANTA ROSA VALLEYS AND OXNARD PLAIN
SCALE
MILES
SANTA BARBARA NATL FOREST
PIRU
BUCKHORN
CAMULOS
CASTAIC
CASTAIC JUNCT
SAUGUS
NEWHALL
HUMPHREYS
SANTA CLARA RIVER
SIMI
SANTA SUSANA
HUTTON PK 2255
SULPHUR MTN
LOMA VERDE PK 2402
SANDY ROCK PK 2851
ROCKY PK 2733
CHATSWORTH PK 2320
CHATSWORTH RES
SIMI PK 2400
IRON MTN
DRINKWATER REGULATING RES
DRY CANYON RES
LOS ANGELES COUNTY
VENTURA COUNTY
LOS ANGELES CITY BOUNDARY
WATERSHED BOUNDARY
SANTA SUSANA MTS
SIMI HILLS
1 STANDARD PARALLEL NORTH - S B BASE
R19W
R18W
R17W
R16W
R15W

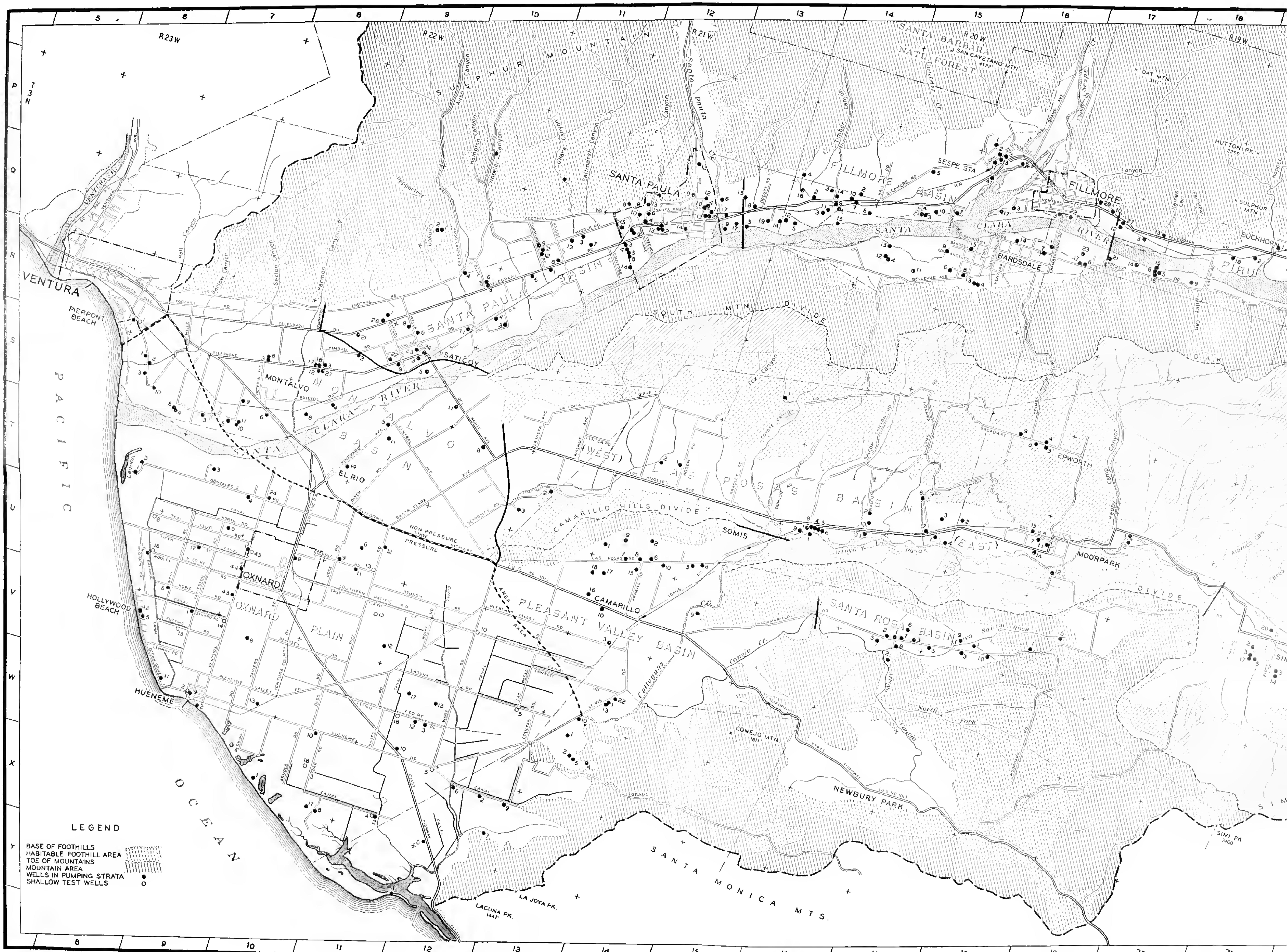

LEGEND
BASE OF FOOTHILLS
HABITABLE FOOTHILL AREA
TOE OF MOUNTAINS
MOUNTAIN AREA
MEASURED WELLS
SANTA BARBARA NATL. FOREST
SANTA YNEZ MTNS DIVIDE
SULPHUR MTN DIVIDE
WATERSHED BOUNDARY
WHEELER SPRS.
MATILIJA HOT SPRS
NORDHOFF PK. 4477
OJAI
OAK VIEW
LA CROSS
VENTURA
RED MT 2158'
VENTURA CITY RESERVOIR
PACIFIC OCEAN
R 24 W
R 23 W
R 22 W
T 5 N
T 4 N
T 3 N
SCALE
MILES
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
LINES OF EQUAL CHANGE
IN
GROUND WATER TABLE
FALL OF 1931 TO FALL OF 1932
IN
VENTURA RIVER AND OJAI VALLEYS

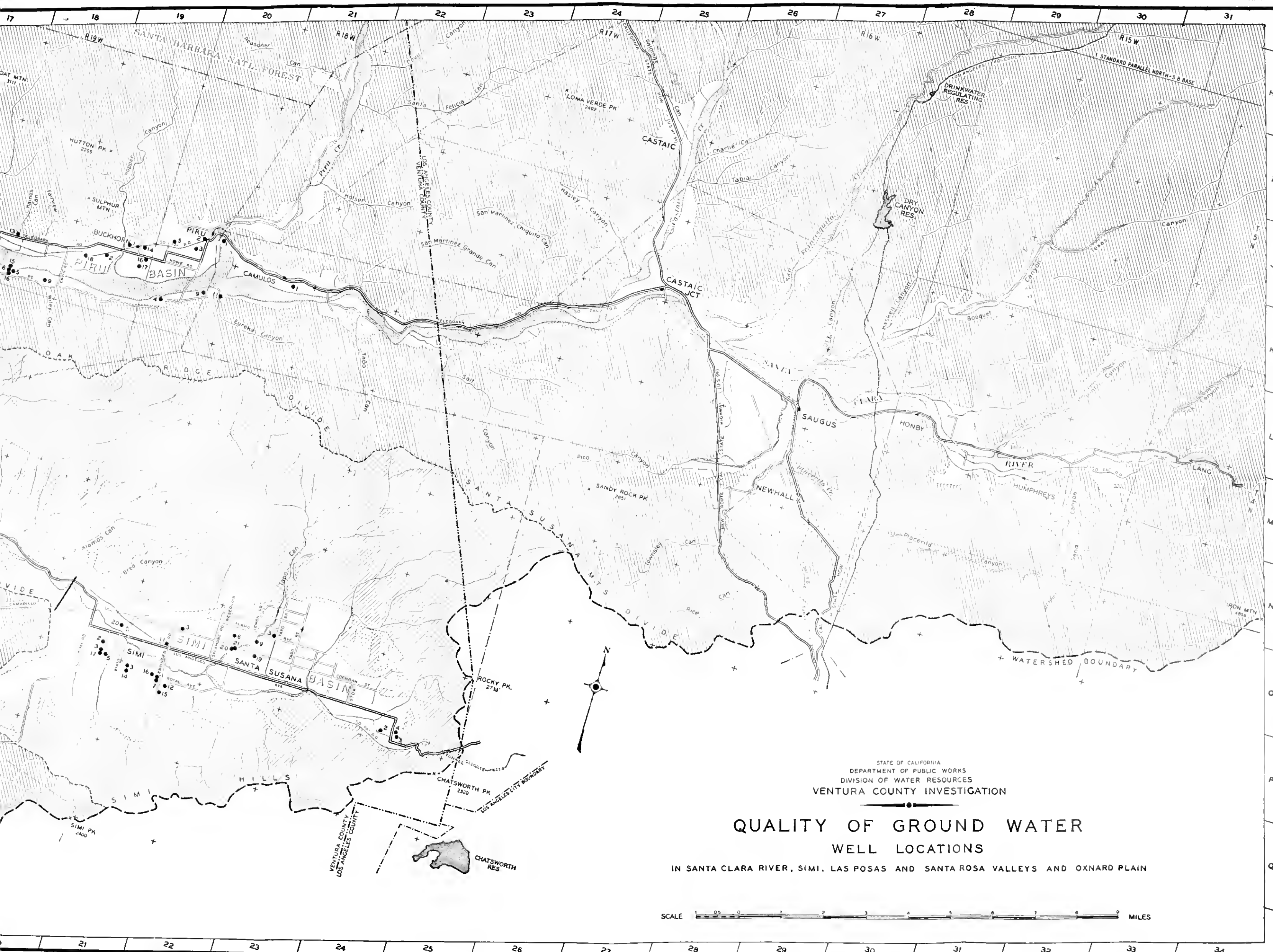


VENTURA
SANTA PAULA
FILLMORE
SATICOY
MONTALVO
EL RIO
OXNARD
CAMARILLO
SOMIS
MOORPARK
EPWORTH
BARDSDALE
HUENEME
HOLLYWOOD BEACH
PIERPONT BEACH
NEWBURY PARK
PACIFIC
OCEAN
SANTA CLARA RIVER
SULPHUR MOUNTAIN
SOUTH MTN DIVIDE
CAMARILLO HILLS DIVIDE
SANTA MONICA MTS.
SANTA BARBARA NATL FOREST
CONEJO MTN
LAGUNA PK
LA JOYA PK
R23W
R22W
R21W
R20W
R19W
BASE OF FOOTHILLS
HABITABLE FOOTHILL AREA
TOE OF MOUNTAINS
MOUNTAIN AREA
MEASURED WELLS


STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
LINES OF EQUAL CHANGE
IN
GROUND WATER TABLE
FALL OF 1931 TO FALL OF 1932
IN
SANTA CLARA RIVER, SIMI, LAS POSAS, SANTA ROSA VALLEYS AND OXNARD PLAIN
SCALE
MILES
SANTA BARBARA NAT'L FOREST
LOS ANGELES COUNTY
VENTURA COUNTY
CASTAIC
CASTAIC JCT.
SAUGUS
NEWHALL
HONBY
HUMPHREYS
FIRU
BUCKHORN
CAMULOS
SIMI
SANTA SUSANA
DRY CANYON RES.
DRINKWATER REGULATING RES.
CHATSWORTH RES.
CHATSWORTH PK.
ROCKY PK.
SIMI PK.
LOMA VERDE PK.
HUTTON PK.
SANDY ROCK PK.
IRON MTN.
SULPHUR MTN.
SANTA CLARA RIVER
SANTA SUSANA MTS. DIVIDE
SIMI HILLS
OAK RIDGE DIVIDE
WATERSHED BOUNDARY
LOS ANGELES CITY BOUNDARY
STANDARD PARALLEL NORTH - S B BASE
R 19 W
R 18 W
R 17 W
R 16 W
R 15 W


STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
QUALITY OF GROUND WATER
WELL LOCATIONS
IN OJAI AND VENTURA RIVER VALLEYS
LEGEND
BASE OF FOOTHILLS
HABITABLE FOOTHILL AREA
TOE OF MOUNTAINS
MOUNTAIN AREA
WELLS IN PUMPING STRATA
SCALE
MILES
R 24 W
R 23 W
R 22 W
T 5 N
T 4 N
T 3 N
SANTA BARBARA NATL. FOREST
WHEELER SPRS
NORDHOFF PK 4477
MATILIJA HOT SPRS
SANTA YNEZ MTNS DIVIDE
OJAI
OJAI BASIN
UPPER VENTURA RIVER BASIN
LOWER VENTURA RIVER BASIN
OAK VIEW
LA CROSS
SULPHUR MTN DIVIDE
WATERSHED BOUNDARY
RED MT 2158'
VENTURA CITY RESERVOIR
VENTURA
PACIFIC OCEAN
CAL STATE HGW (U.S. 101)
SOU PAC R.R.
FOOTHILL RD
TELEGRAPH RD
THOMPSON BLVD
MAIN ST
Canada Larga
Canada de Aliso
Coche Can
Sulphur Can
Hammond Can
Leon Can
Weldon Can
Manuel Can
Canada de San Joaquin
Hall Canyon
Canada de Rodriguez
Canada del Diablo
Padre Juan Can
Santa Ana Cr
Ayers Cr
Willow Cr
Poplin
East Fk
Kennedy Can
Rice Can
Cozy Dell Can
Stewart Can
Gridley
Senor Can
Horn Can
Sisar Cr
Bear Can
Big Can
San Antonio
Lion Can
Fresno Can
Matilija Cr
Donald


R 23 W
R 22 W
R 21 W
R 20 W
R 19 W
T 3 N
SULPHUR MOUNTAIN
SANTA BARBARA NAT'L FOREST
SAN CAYETANO MTN
OAT MTN
HUTTON PK.
SULPHUR MTN
VENTURA
PIERPONT BEACH
SANTA PAULA
FILLMORE
FILLMORE BASIN
SESPE STA
BARDSDALE
SANTA CLARA RIVER
BUCKHORN
PIRU
SANTA PAULA BASIN
SOUTH MTN DIVIDE
SATICOY
MONTALVO
MONTALVO BASIN
EL RIO
PACIFIC
OCEAN
(WEST) LAS POSAS BASIN (EAST)
EPWORTH
MOORPARK
CAMARILLO HILLS DIVIDE
SOMIS
NON PRESSURE
PRESSURE
OXNARD
OXNARD PLAIN
HOLLYWOOD BEACH
HUENEME
CAMARILLO
PLEASANT VALLEY BASIN
PRESSURE AREA
SANTA ROSA BASIN
DIVIDE
CONEJO MTN
NEWBURY PARK
SANTA MONICA MTS.
LAGUNA PK.
LA JOYA PK.
SIMI PK
LEGEND
BASE OF FOOTHILLS
HABITABLE FOOTHILL AREA
TOE OF MOUNTAINS
MOUNTAIN AREA
WELLS IN PUMPING STRATA
SHALLOW TEST WELLS


STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
QUALITY OF GROUND WATER
WELL LOCATIONS
IN SANTA CLARA RIVER, SIMI, LAS POSAS AND SANTA ROSA VALLEYS AND OXNARD PLAIN
SCALE
MILES
SANTA BARBARA NATL FOREST
R19W
R18W
R17W
R16W
R15W
1 STANDARD PARALLEL NORTH - S B BASE
LOS ANGELES AQUEDUCT
DRINKWATER REGULATING RES
LOMA VERDE PK 2492
HUTTON PK 2255
SULPHUR MTN
CASTAIC
CASTAIC JCT
DRY CANYON RES
LOS ANGELES COUNTY
VENTURA COUNTY
PIRU
BUCKHORN
PIRU BASIN
CAMULOS
HOWE RD
OAK RIDGE
DIVIDE
SAUGUS
HONBY
NEWHALL
SANTA CLARA RIVER
LANG
HUMPHREYS
SANDY ROCK PK 2851
SANTA SUSANA MTS DIVIDE
WATERSHED BOUNDARY
IRON MTN 4856
SIMI
SANTA SUSANA
SIMI SANTA SUSANA BASIN
ROCKY PK 2733'
CHATSWORTH PK 2320
LOS ANGELES CITY BOUNDARY
SIMI HILLS
SIMI PK 2400
CHATSWORTH RES
VENTURA COUNTY
LOS ANGELES COUNTY
N


R 23 W
R 22 W
R 21 W
T 3 N
SULPHUR MOUNTAIN
SANTA PAULA
VENTURA
PIERPONT BEACH
SATICOY
MONTALVO
SANTA CLARA RIVER
EL RIO
SOUTH MTN DIVIDE
CAMARILLO HILLS DIVIDE
SOMIS
OXNARD
CAMARILLO
HOLLYWOOD BEACH
HUENEME
CONEJO MTN 1811
SANTA MONICA MTS
LA JOYA PK
LAGUNA PK 1447
LEGEND
CITRUS & AVOCADOS
APRICOTS, MISC. TREES & GRAPES
BEANS, BEETS & HAY
WALNUTS
ALFALFA
TRUCK & MISC. GARDEN
SUBDIVISION
UNIRRIGATED VALLEY LANDS
BASE OF FOOTHILLS
HABITABLE FOOTHILL AREA
TOE OF MOUNTAINS
MOUNTAIN AREA

14
15
16
17
18
19
20
21
22
R 20 W
R 19 W
R 18 W
SANTA BARBARA NATL. FOREST
SAN CAYETANO MTN
4122
OAT MTN
3111
HUTTON PK
2255
SULPHUR MTN
FILLMORE
SANTA CLARA RIVER
BARDSDALE
PIRU
Reasoner
Holser
Canyon
LOS ANGELES COUNTY
VENTURA COUNTY
Eureka Canyon
OAK RIDGE
DIVIDE
EPWORTH
MOORPARK
Alamos Can
Brea Canyon
DIVIDE
SIMI
SANTA SUSANA
NEWBURY PARK
North Fork
SIMI HILLS
SIMI PK
2400
CHATSWORTH
VENTURA COUNTY
LOS ANGELES COUNTY
T 5
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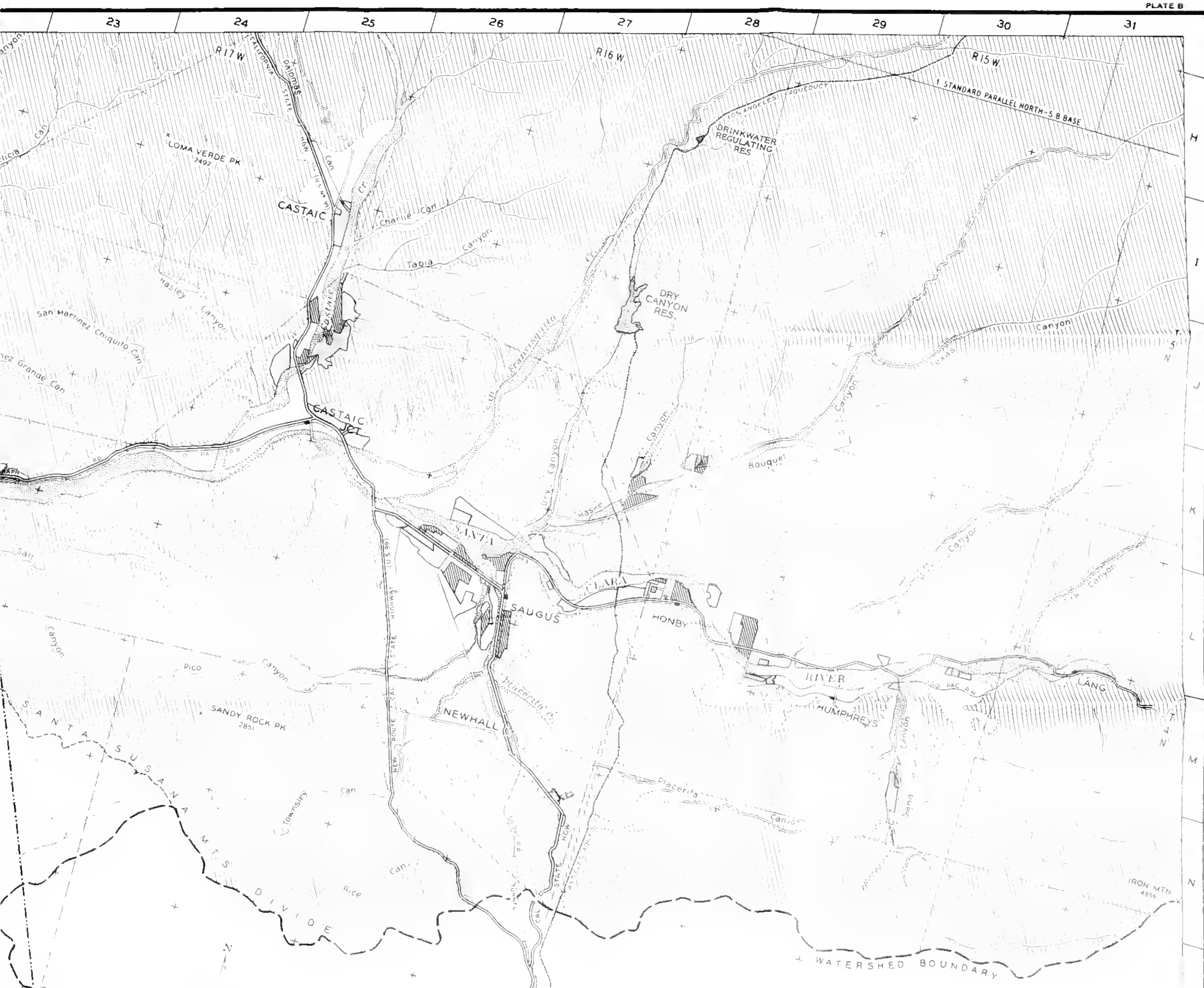
25



NET IRRIGATED AREA 1932

ACRES

	Citrus and Avocados	Apricots, Misc. Trees, Grapes	Walnuts	Beans, Beets and Hay	Alfalfa	Truck and Misc. Gardens	Domestic Requirements	Total Irrigated	Unirrigated Valley Areas
Santa Clara Valley—from Camulos East	359	142		700	1 062	615		2 878	22 402
Santa Clara Valley—from Camulos to Saticoy	13 656	499	5 503	1 464	626	589	1 113	24 380	25 351
Ventura	6	2	145	18		37	1 092	1 300	[illegible]
North of Santa Clara River—Saticoy West	1 529	65	4 202	2 676	122	118	[illegible]	[illegible]	[illegible]
Oxnard Plain	2 929	226	7 430	21 412	3 548	2,651	1,234	34,959	[illegible]
Moorpark Area	1 487	616	3 487	[illegible]	[illegible]	140	[illegible]	11 294	7 835
Pleasant Valley	1 024	57	3 160	9 515	642	841	86	[illegible]	5 599
Santa Rosa Valley	1 322	256	352	523	[illegible]	603		[illegible]	5 716
Simi Valley	1 355	749	2 863	1 142	104	912	37	[illegible]	[illegible]
Ventura River Valley	1 721	441	266	215	90	687	1 015	4 535	15 660
Totals	25,388	3 553	22 394	44 527	6 411	7,193	4 725	114,193	104 433

STATE OF CALIFORNIA

DEPARTMENT OF PUBLIC WORKS

DIVISION OF WATER RESOURCES

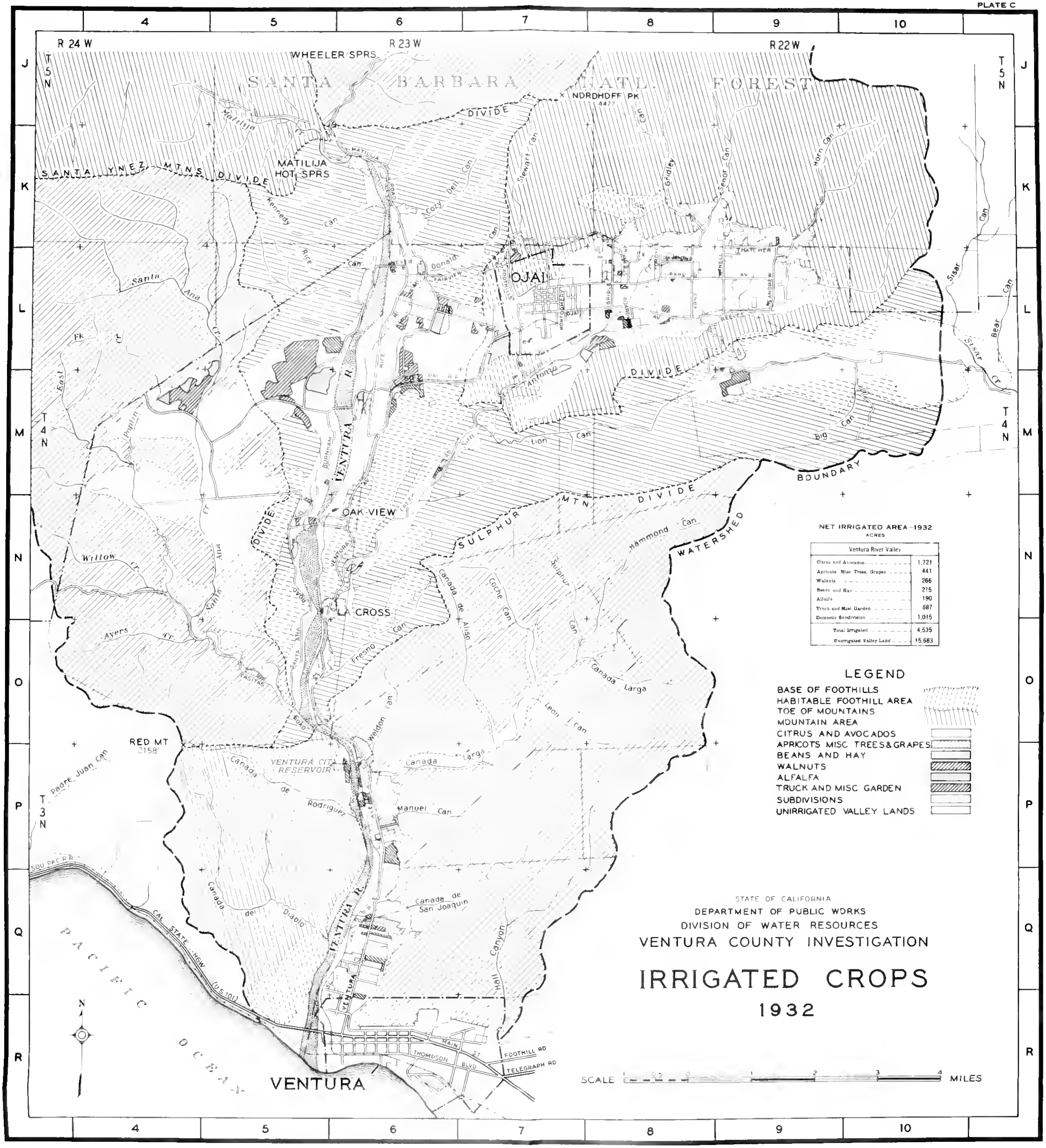
VENTURA COUNTY INVESTIGATION

IRRIGATED CROPS

1932

SCALE 1 0.5 0 1 2 3 4 5 6 7 8 9 MILES

26 27 28 29 30 31 32 33 34


STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
IRRIGATED CROPS
1932
NET IRRIGATED AREA–1932
ACRES
Ventura River Valley
Citrus and Avocados 1,721
Apricots Misc Trees, Grapes 441
Walnuts 266
Beans and Hay 215
Alfalfa 190
Truck and Misc Garden 687
Domestic Subdivision 1,015
Total Irrigated 4,535
Unirrigated Valley Land 15,683
LEGEND
BASE OF FOOTHILLS
HABITABLE FOOTHILL AREA
TOE OF MOUNTAINS
MOUNTAIN AREA
CITRUS AND AVOCADOS
APRICOTS MISC TREES & GRAPES
BEANS AND HAY
WALNUTS
ALFALFA
TRUCK AND MISC GARDEN
SUBDIVISIONS
UNIRRIGATED VALLEY LANDS
SCALE
MILES
SANTA BARBARA NATL. FOREST
WHEELER SPRS
MATILIJA HOT SPRS
NORDHOFF PK
OJAI
OAK VIEW
LA CROSS
VENTURA CITY RESERVOIR
RED MT
VENTURA
PACIFIC OCEAN
SULPHUR MTN DIVIDE
WATERSHED BOUNDARY
SANTA YNEZ MTNS DIVIDE
R 24 W
R 23 W
R 22 W
T 5 N
T 4 N
T 3 N